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# Spectrum of $H_2{}^{18}O$ and $H_2{}^{17}O$ in the 5030 to 5640 $cm^{-1}$ Region[1]

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Measurements of line center positions of $H_2{}^{18}O$ and $H_2{}^{17}O$ in the 5030 to 5640 $cm^{-1}$ region have been made at high resolution. This region contains absorptions of the (011) and (110) bands of $H_2{}^{18}O$ and $H_2{}^{17}O$. Values of the ground state levels of $H_2{}^{18}O$ and $H_2{}^{17}O$ as well as those for the states of (011) and (110) of $H_2{}^{18}O$ and $H_2{}^{17}O$ were determined from the data. Strength measurements of 23 strong absorbing lines of $H_2{}^{18}O$ were also included and compared to values obtained for $H_2{}^{16}O$ multiplied by the $O^{18}/O^{16}$ isotopic abundance ratio. These results indicate that $H_2{}^{18}O$ line strengths can be calculated, to good approximation, from the $H_2{}^{16}O$ values for the (011) and (110) bands.

## INTRODUCTION

The present study was undertaken to obtain a knowledge of the line positions of $H_2{}^{18}O$ and $H_2{}^{17}O$ in the 1.9 $\mu$m spectral region which, in turn, is important for the interpretation of atmospheric spectra. The $H_2{}^{18}O$ data were obtained in the same manner as those presented for the 2900 to 3400 $cm^{-1}$ region published earlier by Toth and Margolis (*1*). Additional spectra of $H_2{}^{16}O$, which contained absorption of $H_2{}^{18}O$ and $H_2{}^{17}O$, were also used for purposes of line position measurements (*2*) and line strength measurements (*3*).

This work encompasses measurements of the line positions in the (011) and (110) bands of $H_2{}^{18}O$ and $H_2{}^{17}O$ as well as obtaining values for the ground state and upper state levels. Also strength measurements of 23 $H_2{}^{18}O$ lines are presented.

## EXPERIMENTAL DETAILS

The data were obtained with a 1.8 m Jarrel–Ash grating spectrometer having a 300 line/mm grating blazed at 5.7 $\mu$m in first order. Observations were made in third order at a spectral resolution of $\sim$0.05 $cm^{-1}$. The source was a 1000 W quartz–iodine projection lamp and the detector was a PbS element which was cooled to approximately $-60°C$. A multitraversal cell of 2 m base length was used for all measurements. The

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TABLE 1. GROUND STATE ENERGY LEVELS ($CM^{-1}$) OF $H_2{}^{18}O$ AND $H_2{}^{17}O$

| $JK_{-1}K_1$ | $H_2{}^{18}O$ This Work | $H_2{}^{18}O$ Garing and McClatchey[a] | $H_2{}^{18}O$ Toth and Margolis[b] | $H_2{}^{17}O$ This Work | $H_2{}^{17}O$ Garing and McClatchey[a] |
|---|---|---|---|---|---|
| 0 0 0 | .000 | .000 | .000 | .000 | .000 |
| 1 0 1 | 23.756 | 23.755 | 23.756 | 23.775 | 23.773 |
| 1 1 1 | 36.750 | 36.749 | 36.750 | 36.940 | 36.932 |
| 1 1 0 | 42.024 | 42.024 | 42.024 | 42.190 | 42.188 |
| 2 0 2 | 69.928 | 69.927 | 69.930 | 70.010 | 70.004 |
| 2 1 2 | 78.990 | 78.989 | 78.995 | 79.236 | 79.228 |
| 2 1 1 | 94.789 | 94.788 | 94.790 | 94.973 | 94.970 |
| 2 2 1 | 133.477 | 133.476 | 133.480 | 134.141 | 134.149 |
| 2 2 0 | 134.785 | 134.783 | 134.785 | 135.425 | 135.435 |
| 3 0 3 | 136.338 | 136.336 | 136.344 | 136.540 | 136.536 |
| 3 1 3 | 141.568 | 141.568 | 141.577 | 141.908 | 141.902 |
| 3 1 2 | 172.884 | 172.882 | 172.888 | 173.107 | 173.109 |
| 3 2 2 | 204.758 | 204.756 | 204.763 | 205.477 | 205.485 |
| 3 2 1 | 210.800 | 210.799 | 210.800 | 211.435 | 211.439 |
| 3 3 1 | 282.095 | 282.095 | 282.093 | 283.570 | 283.570 |
| 3 3 0 | 282.306 | 282.307 | 282.304 | 283.775 | 283.776 |
| 4 0 4 | 221.234 | 221.234 | 221.237 | 221.623 | 221.619 |
| 4 1 4 | 223.829 | 223.828 | 223.830 | 224.305 | 224.304 |
| 4 1 3 | 274.803 | 274.803 | 274.793 | 275.116 | 275.129 |
| 4 2 3 | 298.621 | 298.620 | 298.629 | 299.434 | 299.442 |
| 4 2 2 | 314.461 | 314.460 | 314.460 | 315.068 | 315.082 |
| 4 3 2 | 379.291 | 379.293 | 379.293 | 380.813 | 380.815 |
| 4 3 1 | 380.703 | 380.704 | 380.700 | 382.180 | 382.186 |
| 4 4 1 | 482.646 | 482.645 | 482.632 | 485.238 | 485.226 |
| 4 4 0 | 482.676 | 482.674 | 482.660 | 485.260 | 485.254 |
| 5 0 5 | 324.047 | 324.047 | 324.044 | 324.660 | 324.660 |

| $JK_{-1}K_1$ | $H_2{}^{18}O$ This Work | $H_2{}^{18}O$ Garing and McClatchey[a] | $H_2{}^{18}O$ Toth and Margolis[b] | $H_2{}^{17}O$ This Work | $H_2{}^{17}O$ Garing and McClatchey[a] |
|---|---|---|---|---|---|
| 8 0 8 | 740.918 | 740.913 | 740.930 | 742.414 | 742.403 |
| 8 1 8 | 740.999 | 741.000 | 741.000 | 742.505 | 742.496 |
| 8 1 7 | 879.493 | 879.495 | 879.481 | 881.103 | 881.098 |
| 8 2 7 | 881.917 | 881.914 | 881.900 | 883.659 | 883.656 |
| 8 2 6 | 980.229 | 980.227 | 980.230 | 981.504 | 981.497 |
| 8 3 6 | 1001.711 | 1001.711 | 1001.709 | 1003.802 | 1003.796 |
| 8 3 5 | 1047.331 | 1047.336 | 1047.317 | | 1048.672 |
| 8 4 5 | 1116.639 | 1116.646 | 1116.620 | | 1119.516 |
| 8 4 4 | 1126.443 | 1126.449 | 1126.480 | | 1128.971 |
| 8 5 4 | 1246.380 | 1246.381 | 1246.369 | | 1250.540 |
| 8 5 3 | 1247.210 | 1247.218 | 1247.200 | | 1251.333 |
| 8 6 3 | 1399.437 | 1399.434 | 1399.740 | | 1405.199 |
| 8 6 2 | 1399.471 | 1399.469 | | | 1405.232 |
| 8 7 2 | 1574.658 | 1574.630 | | | 1582.245 |
| 8 7 1 | 1574.658 | 1574.630 | | | 1582.244 |
| 8 8 1 | | 1768.750 | | | 1778.395 |
| 8 8 0 | | 1768.750 | | | 1778.395 |
| 9 0 9 | 916.258 | 916.261 | 916.250 | 918.102 | 918.111 |
| 9 1 9 | 916.297 | 916.297 | 916.300 | 918.157 | 918.150 |
| 9 1 8 | 1074.763 | 1074.761 | 1074.779 | 1076.823 | 1076.802 |
| 9 2 8 | 1075.911 | 1075.907 | 1075.920 | | |
| 9 2 7 | 1198.210 | 1198.207 | 1198.190 | | 1199.964 |
| 9 3 7 | 1211.191 | 1211.193 | | | 1213.579 |
| 9 3 6 | 1279.800 | 1279.809 | 1279.800 | | |
| 9 4 6 | 1334.485 | 1334.494 | 1334.680 | | 1337.522 |
| 9 4 5 | 1355.221 | 1355.214 | 1355.190 | | 1357.593 |
| 9 5 5 | 1466.029 | 1466.040 | | | 1470.274 |
| 9 5 4 | 1468.616 | 1468.634 | | | 1472.737 |
| 9 6 4 | 1618.910 | 1618.920 | | | 1624.756 |
| 9 6 3 | 1619.071 | 1619.079 | | | 1624.905 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | 1 | 5 | 325.216 | 325.216 | 325.216 | 325.880 | 325.881 |
| 5 | 1 | 4 | 398.361 | 398.361 | 398.372 | 398.874 | 398.877 |
| 5 | 2 | 4 | 414.170 | 414.170 | 414.177 | 415.124 | 415.132 |
| 5 | 2 | 3 | 445.159 | 445.159 | 445.160 | 445.787 | 445.796 |
| 5 | 3 | 3 | 500.597 | 500.598 | 500.595 | 502.180 | 502.190 |
| 5 | 3 | 2 | 505.730 | 505.730 | 505.727 | 507.183 | 507.185 |
| 5 | 4 | 2 | 604.547 | 604.548 | 604.550 | 607.187 | 607.178 |
| 5 | 4 | 1 | 604.794 | 604.793 | 604.796 | 607.422 | 607.415 |
| 5 | 5 | 1 | 733.681 | 733.684 | 733.673 | | 737.652 |
| 5 | 5 | 0 | 733.685 | 733.688 | 733.678 | | 737.656 |
| 6 | 0 | 6 | 444.853 | 444.848 | 444.860 | 445.729 | 445.720 |
| 6 | 1 | 6 | 445.346 | 445.346 | 445.355 | 446.250 | 446.246 |
| 6 | 1 | 5 | 541.179 | 541.181 | 541.183 | 541.991 | 541.994 |
| 6 | 2 | 5 | 550.453 | 550.453 | 550.447 | 551.605 | 551.613 |
| 6 | 2 | 4 | 601.238 | 601.240 | 601.246 | 601.954 | 601.964 |
| 6 | 3 | 4 | 645.385 | 645.387 | 645.387 | 647.081 | 647.084 |
| 6 | 3 | 3 | 658.609 | 658.614 | 658.623 | 659.994 | 660.001 |
| 6 | 4 | 3 | 751.036 | 751.038 | 751.040 | 753.733 | 753.726 |
| 6 | 4 | 2 | 752.191 | 752.192 | 752.195 | 754.838 | 754.834 |
| 6 | 5 | 2 | 880.080 | 880.080 | 880.079 | | 884.109 |
| 6 | 5 | 1 | 880.115 | 880.119 | 880.121 | | 884.146 |
| 6 | 6 | 1 | 1033.195 | 1033.194 | 1033.195 | | 1038.815 |
| 6 | 6 | 0 | 1033.195 | 1033.194 | 1033.195 | | 1038.815 |
| 7 | 0 | 7 | 583.782 | 583.780 | 583.767 | 584.937 | 584.944 |
| 7 | 1 | 7 | 583.985 | 583.989 | 583.972 | 585.157 | 585.165 |
| 7 | 1 | 6 | 701.695 | 701.695 | 701.697 | 702.887 | 702.884 |
| 7 | 2 | 6 | 706.599 | 706.599 | 706.608 | 708.025 | 708.020 |
| 7 | 2 | 5 | 780.456 | 780.454 | 780.440 | 781.371 | 781.378 |
| 7 | 3 | 5 | 812.766 | 812.767 | 812.753 | 814.618 | 814.624 |
| 7 | 3 | 4 | 839.555 | 839.555 | 839.561 | 840.873 | 840.880 |
| 7 | 4 | 4 | 921.900 | 921.903 | 921.910 | | 924.666 |
| 7 | 4 | 3 | 925.704 | 925.707 | 925.698 | | 928.323 |
| 7 | 5 | 3 | 1050.994 | 1050.991 | 1050.990 | | 1055.086 |
| 7 | 5 | 2 | 1051.207 | 1051.204 | 1051.210 | | 1055.287 |
| 7 | 6 | 2 | 1204.170 | 1204.169 | 1204.172 | | 1209.861 |
| 7 | 6 | 1 | 1204.177 | 1204.174 | 1204.186 | | 1209.866 |
| 7 | 7 | 1 | 1378.970 | 1378.961 | 1378.980 | | 1386.486 |
| 7 | 7 | 0 | 1378.970 | 1378.961 | 1378.980 | | 1386.486 |
| 9 | 7 | 3 | | 1794.360 | | | 1802.047 |
| 9 | 7 | 2 | | 1794.360 | | | 1802.049 |
| 9 | 8 | 2 | | 1989.305 | | | 1999.034 |
| 9 | 8 | 1 | | 1989.305 | | | 1999.034 |
| 9 | 9 | 1 | | 2200.430 | | | 2212.332 |
| 9 | 9 | 0 | | 2200.430 | | | 2212.332 |
| 10 | 0 | 10 | 1109.785 | 1109.790 | 1109.808 | | 1112.037 |
| 10 | 1 | 10 | 1109.801 | 1109.805 | 1109.770 | | 1112.054 |
| 10 | 1 | 9 | 1287.727 | 1287.730 | 1287.727 | | 1290.230 |
| 10 | 2 | 9 | 1288.271 | 1288.262 | 1288.264 | | 1290.802 |
| 10 | 2 | 8 | 1433.030 | 1433.048 | 1433.061 | | |
| 10 | 3 | 8 | 1440.291 | 1440.300 | 1440.295 | | 1443.061 |
| 10 | 3 | 7 | 1534.385 | 1534.391 | 1534.368 | | 1536.169 |
| 10 | 4 | 7 | 1574.458 | 1574.475 | | | |
| 10 | 4 | 6 | 1611.673 | 1611.680 | | | 1613.941 |
| 10 | 5 | 6 | 1709.575 | 1709.580 | | | |
| 10 | 5 | 5 | | 1716.240 | | | 1720.252 |
| 10 | 6 | 5 | | 1862.510 | | | 1868.413 |
| 10 | 6 | 4 | | 1863.050 | | | 1868.929 |
| 10 | 7 | 4 | | 2037.980 | | | 2045.732 |
| 11 | 0 | 11 | 1321.457 | 1321.456 | 1321.440 | | 1324.137 |
| 11 | 1 | 11 | 1321.464 | 1321.462 | | | 1324.144 |
| 11 | 1 | 10 | 1518.541 | 1518.534 | 1518.550 | | |
| 11 | 2 | 10 | 1518.798 | 1518.779 | | | |
| 11 | 2 | 9 | 1684.437 | 1684.462 | | | |
| 11 | 3 | 8 | 1808.380 | 1808.410 | | | |
| 11 | 5 | 6 | | 1990.880 | | | |
| 12 | 0 | 12 | 1551.195 | 1551.200 | | | 1554.352 |
| 12 | 1 | 12 | 1551.195 | 1551.203 | 1551.190 | | 1554.355 |
| 12 | 1 | 11 | 1767.211 | 1767.218 | | | |
| 12 | 2 | 11 | 1767.335 | 1767.331 | | | |

TABLE 2. ENERGY LEVELS ($CM^{-1}$) IN THE (011) AND (110) STATES OF $H_2{}^{18}O$ AND $H_2{}^{17}O$

| $JK_{-1}K_1$ | $H_2{}^{18}O$ (011) | $H_2{}^{18}O$ (110) | $H_2{}^{17}O$ (011) | $H_2{}^{17}O$ (110) |
|---|---|---|---|---|
| 0 0 0 | 5310.468 | 5221.240 | 5320.262 | |
| 1 0 1 | 5334.023 | 5244.640 | 5343.834 | |
| 1 1 1 | 5348.568 | 5259.985 | 5358.547 | |
| 1 1 0 | 5354.201 | 5265.542 | 5364.154 | |
| 2 0 2 | 5379.769 | 5290.130 | 5389.637 | |
| 2 1 2 | 5390.103 | 5301.217 | 5400.130 | |
| 2 1 1 | 5406.954 | 5317.853 | 5416.941 | |
| 2 2 1 | 5450.103 | 5363.370 | 5460.568 | |
| 2 2 0 | 5451.442 | 5364.606 | 5461.889 | |
| 3 0 3 | 5445.418 | 5355.559 | 5455.406 | |
| 3 1 3 | 5451.680 | 5362.298 | 5461.777 | |
| 3 1 2 | 5484.981 | 5395.298 | 5495.007 | |
| 3 2 2 | 5523.817 | 5433.551 | 5533.085 | |
| 3 2 1 | 5527.726 | 5439.257 | 5538.018 | |
| 3 3 1 | 5605.981 | 5521.681 | 5617.260 | |
| 3 3 0 | 5606.193 | 5519.538 | 5617.467 | 5528.927 |
| 4 0 4 | 5529.087 | 5439.043 | 5539.244 | |
| 4 1 4 | 5531.870 | 5442.596 | 5541.497 | |
| 4 1 3 | 5586.738 | 5496.472 | 5596.873 | |
| 4 2 3 | 5620.552 | 5525.994 | 5629.243 | |
| 4 2 2 | 5630.881 | 5541.921 | 5641.289 | |
| 4 3 2 | 5702.272 | 5617.515 | 5713.560 | |
| 4 3 1 | 5703.664 | 5612.642 | 5714.923 | 5622.644 |
| 4 4 1 | 5815.712 | 5736.450 | 5828.140 | |
| 4 4 0 | 5815.737 | 5736.460 | 5828.140 | |
| 5 0 5 | 5630.105 | 5539.817 | 5640.482 | |
| 5 1 5 | 5631.461 | 5541.514 | 5641.866 | |
| 5 1 4 | 5709.973 | 5619.296 | | |
| 5 2 4 | 5727.507 | 5639.810 | 5737.990 | |
| 5 2 3 | 5761.125 | 5670.875 | | |
| 5 3 3 | 5822.473 | 5737.172 | 5833.793 | |
| 5 3 2 | 5827.516 | 5743.006 | | |
| 5 4 2 | 5936.606 | 5856.963 | 5949.029 | |
| 5 4 1 | 5936.846 | 5857.093 | | |
| 5 5 1 | 6077.104 | | | |
| 5 5 0 | 6077.104 | | | |
| 6 0 6 | 5748.526 | 5657.883 | 5759.134 | |
| 6 1 6 | 5749.126 | 5658.661 | 5759.760 | |
| 6 1 5 | 5852.207 | 5761.359 | | |
| 6 2 5 | 5862.757 | 5774.148 | | |
| 6 2 4 | 5916.636 | 5825.524 | | |
| 6 3 4 | 5966.010 | 5880.040 | | |
| 6 3 3 | 5978.891 | 5892.851 | | |
| 6 4 3 | 6081.881 | 6001.786 | | |
| 6 4 2 | 6082.984 | 6002.304 | | |
| 6 5 2 | 6222.401 | | | |
| 6 5 1 | 6222.437 | | | |
| 6 6 1 | 6367.471 | | | |
| 6 6 0 | 6387.474 | | | |
| 7 0 7 | ·5884.521 | 5793.412 | 5895.396 | |
| 7 1 7 | 5884.772 | 5793.748 | 5895.651 | |
| 7 1 6 | 6011.698 | 5920.794 | | |
| 7 2 6 | 6017.424 | | | |
| 7 2 5 | 6095.718 | | | |
| 7 3 5 | 6132.045 | | | |
| 7 3 4 | 6157.370 | 6070.701 | | |
| 7 4 4 | 6251.325 | 6171.565 | | |
| 7 4 3 | 6254.958 | 6172.836 | | |
| 7 5 3 | 6391.987 | | | |
| 7 5 2 | 6392.181 | | | |
| 7 6 2 | 6557.260 | | | |
| 7 6 1 | 6557.260 | | | |
| 7 7 1 | 6744.006 | | | |
| 7 7 0 | 6744.006 | | | |
| 8 0 8 | 6038.161 | | 6049.333 | |
| 8 1 8 | 6038.268 | 5946.610 | | |
| 8 1 7 | 6187.915 | | | |
| 8 2 7 | 6190.820 | | | |
| 8 2 6 | 6295.112 | | | |
| 8 3 6 | 6319.606 | | | |
| 8 3 5 | 6370.513 | | | |
| 8 4 5 | 6444.461 | 6357.185 | | |
| 8 4 4 | 6453.637 | | | |
| 8 5 4 | 6565.772 | | | |
| 8 5 3 | 6566.559 | | | |
| 8 6 3 | 6751.097 | | | |
| 8 6 2 | 6751.113 | | | |
| 8 7 2 | 6938.370 | | | |
| 8 7 1 | 6938.370 | | | |
| 8 8 1 | 7143.339 | | | |
| 8 8 0 | 7143.339 | | | |
| 9 0 9 | 6209.490 | 6117.089 | | |
| 9 1 9 | 6209.536 | 6117.222 | | |
| 9 1 8 | 6381.026 | | | |
| 9 2 8 | 6382.545 | | | |
| 9 2 7 | 6512.524 | | | |
| 9 3 7 | 6527.591 | | | |
| 9 3 6 | 6600.187 | | | |
| 9 4 6 | 6660.556 | | | |
| 9 4 5 | 6680.397 | | | |
| 9 5 5 | 6803.592 | | | |
| 9 5 4 | 6805.985 | | | |
| 9 6 4 | 6968.847 | | | |
| 9 6 3 | 6969.001 | | | |
| 10 0 10 | 6396.476 | 6305.440 | | |
| 10 1 10 | 6398.488 | 6305.440 | | |
| 10 1 9 | 6591.283 | | | |
| 10 2 9 | 6591.930 | | | |
| 10 2 8 | 6746.393 | | | |
| 10 3 8 | 6754.974 | | | |
| 10 3 7 | 6853.438 | | | |
| 10 4 7 | 6898.695 | | | |
| 10 4 6 | 6934.204 | | | |
| 10 5 5 | 7051.211 | | | |
| 11 0 11 | 6605.081 | | | |
| 11 1 11 | 6605.089 | | | |
| 11 1 10 | 6818.865 | | | |
| 11 2 10 | 6819.174 | | | |
| 11 2 9 | 6996.283 | | | |
| 11 3 9 | 7000.899 | | | |
| 11 4 8 | 7157.927 | | | |
| 12 0 12 | 6829.295 | | | |
| 12 1 12 | 6829.295 | | | |
| 12 1 11 | 7063.886 | | | |
| 12 2 11 | 7063.991 | | | |
| 13 0 13 | 7071.007 | | | |
| 13 1 13 | 7071.007 | | | |
| 13 1 12 | 7326.341 | | | |
| 13 2 12 | 7326.347 | | | |

TABLE 3. MEASUREMENTS AND ASSIGNMENTS OF $H_2{}^{18}O$ AND $H_2{}^{17}O$ IN THE 5030 TO 5640 $CM^{-1}$ SPECTRAL REGION

| Line No. | Frequency ($CM^{-1}$) (Obs.) | Frequency ($CM^{-1}$) (Calc.) | Upper State $JK_{-1}K_1$ | Lower State $JK_{-1}K_1$ | Band | Mol. |
|---|---|---|---|---|---|---|
| 1 | 5036.893 | 5036.892 | 3 3 0 | 4 4 1 | 110 | 18 |
| 2 | 5039.005 | 5039.005 | 3 3 1 | 4 4 0 | 110 | 18 |
| 3 | 5041.173 | 5041.171 | 3 2 2 | 4 4 1 | 11 | 18 |
| 3 | 5041.173 | | 10 4 6 | 11 4 7 | 11 | 18 |
| 4 | 5041.323 | 5041.324 | 4 2 2 | 5 3 3 | 110 | 18 |
| 5 | 5045.072 | 5045.058 | 10 3 7 | 11 3 8 | 11 | 18 |
| 5 | 5045.072 | 5045.050 | 3 2 1 | 4 4 0 | 11 | 18 |
| 6 | 5047.834 | 5047.837 | 3 1 3 | 4 2 2 | 110 | 18 |
| 7 | 5051.361 | 5051.364 | 5 1 4 | 6 3 3 | 11 | 18 |
| 8 | 5051.654 | 5051.654 | 11 1 10 | 12 1 11 | 11 | 18 |
| 9 | 5051.839 | 5051.839 | 11 2 10 | 12 2 11 | 11 | 18 |
| 10 | 5052.412 | 5052.413 | 7 0 7 | 8 1 8 | 110 | 18 |
| 11 | 5052.846 | 5052.830 | 7 1 7 | 8 0 8 | 110 | 18 |
| 11 | 5052.846 | 5052.848 | 3 2 2 | 4 3 1 | 110 | 18 |
| 12 | 5053.896 | 5053.886 | 11 0 11 | 12 0 12 | 11 | 18 |
| 12 | 5053.896 | 5053.894 | 11 1 11 | 12 1 12 | 11 | 18 |
| 13 | 5059.967 | 5059.966 | 3 2 1 | 4 3 2 | 110 | 18 |
| 14 | 5061.025 | | 10 5 5 | 11 5 6 | 11 | 18 |
| 15 | 5061.956 | 5061.956 | 10 2 8 | 11 2 9 | 11 | 18 |
| 16 | 5065.802 | 5065.802 | 9 3 6 | 10 3 7 | 11 | 18 |
| 17 | 5068.724 | 5068.724 | 9 4 5 | 10 4 6 | 11 | 18 |
| 18 | 5068.842 | 5068.843 | 5 1 4 | 6 2 5 | 110 | 18 |
| 19 | 5072.391 | 5072.389 | 3 1 3 | 4 3 2 | 11 | 18 |
| 20 | 5072.444 | 5072.453 | 6 2 5 | 7 1 6 | 110 | 18 |
| 21 | 5072.742 | 5072.742 | 10 1 9 | 11 1 10 | 11 | 18 |
| 22 | 5073.132 | 5073.132 | 10 2 9 | 11 2 10 | 11 | 18 |
| 23 | 5073.899 | 5073.898 | 6 0 6 | 7 1 7 | 110 | 18 |
| 24 | 5074.877 | 5074.879 | 6 1 6 | 7 0 7 | 110 | 18 |
| 25 | 5077.019 | 5077.019 | 10 0 10 | 11 0 11 | 11 | 18 |
| 25 | 5077.019 | 5077.024 | 10 1 10 | 11 1 11 | 11 | 18 |
| 26 | 5077.382 | 5077.385 | 8 4 5 | 9 3 6 | 110 | 18 |
| 27 | 5079.495 | 5079.494 | 9 2 7 | 10 2 8 | 11 | 18 |
| 28 | 5081.009 | 5081.008 | 4 1 3 | 5 3 2 | 11 | 18 |
| 29 | 5081.066 | 5081.064 | 2 2 1 | 3 3 0 | 110 | 18 |
| 30 | 5082.302 | 5082.302 | 4 1 3 | 5 2 4 | 110 | 18 |
| 31 | 5082.510 | 5082.511 | 2 2 0 | 3 3 1 | 110 | 18 |
| 32 | 5083.928 | 5083.928 | 4 0 4 | 5 2 3 | 11 | 18 |
| 33 | 5086.100 | 5086.098 | 9 4 6 | 10 4 7 | 11 | 18 |
| 34 | 5087.150 | 5087.149 | 7 1 7 | 7 2 6 | 110 | 18 |
| 35 | 5087.300 | 5087.300 | 9 3 7 | 10 3 8 | 11 | 18 |
| 36 | 5090.421 | 5090.417 | 2 1 2 | 3 2 1 | 110 | 18 |
| 37 | 5090.716 | 5090.713 | 8 3 5 | 9 3 6 | 11 | 18 |
| 38 | 5091.719 | 5091.717 | 7 0 7 | 7 1 6 | 110 | 18 |
| 38 | 5091.719 | 5091.720 | 7 2 6 | 7 4 3 | 11 | 18 |
| 39 | 5093.303 | 5093.299 | 9 1 8 | 10 1 9 | 11 | 18 |
| 40 | 5094.018 | 5094.017 | 9 5 5 | 10 5 6 | 11 | 18 |
| 41 | 5094.270 | 5094.274 | 9 2 8 | 10 2 9 | 11 | 18 |
| 42 | 5094.468 | 5094.471 | 5 0 5 | 6 1 6 | 110 | 18 |
| 43 | 5096.673 | 5096.661 | 5 1 5 | 6 0 6 | 110 | 18 |
| 43 | 5096.673 | 5096.677 | 3 1 2 | 4 2 3 | 110 | 18 |
| 44 | 5096.902 | 5096.902 | 8 2 6 | 9 2 7 | 11 | 18 |
| 45 | 5098.633 | 5098.631 | 5 2 4 | 6 1 5 | 110 | 18 |
| 45 | 5098.633 | 5098.616 | 8 4 4 | 9 4 5 | 11 | 18 |
| 46 | 5099.735N | 5099.705 | 9 0 9 | 10 0 10 | 11 | 18 |
| 46 | 5099.735N | 5099.735 | 9 1 9 | 10 1 10 | 11 | 18 |
| 47 | 5104.280 | 5104.278 | 3 1 2 | 4 3 1 | 11 | 18 |
| 48 | 5108.010 | 5108.008 | 2 1 2 | 3 3 1 | 11 | 18 |
| 49 | 5108.209 | 5108.208 | 6 1 6 | 6 2 5 | 110 | 18 |
| 50 | 5108.414 | 5108.415 | 8 3 6 | 9 3 7 | 11 | 18 |
| 51 | 5109.977 | 5109.976 | 8 4 5 | 9 4 6 | 11 | 18 |
| 52 | 5110.036 | 5110.039 | 7 3 4 | 8 3 5 | 11 | 18 |
| 53 | 5113.151 | 5113.095 | 2 1 1 | 3 2 2 | 110 | 18 |
| 53 | 5113.151 | 5113.152 | 8 1 7 | 9 1 8 | 11 | 18 |
| 54 | 5114.910 | 5114.909 | 8 2 7 | 9 2 8 | 11 | 18 |
| 55 | 5115.495 | 5115.489 | 7 2 5 | 8 2 6 | 11 | 18 |
| 56 | 5116.671 | 5116.704 | 6 0 6 | 6 1 5 | 110 | 18 |
| 57 | 5117.943 | 5117.943 | 8 5 3 | 9 5 4 | 11 | 18 |
| 58 | 5118.547 | 5118.549 | 4 1 4 | 5 0 5 | 110 | 18 |
| 59 | 5119.743 | 5119.743 | 8 5 4 | 9 5 5 | 11 | 18 |
| 60 | 5121.903N | 5121.903 | 8 0 8 | 9 0 9 | 11 | 18 |
| 61 | 5121.975N | 5121.971 | 8 1 8 | 9 1 9 | 11 | 18 |
| 62 | 5122.711 | 5122.713 | 5 2 4 | 5 4 1 | 11 | 18 |
| 63 | 5124.232 | 5124.234 | 7 4 4 | 8 3 5 | 110 | 18 |
| 64 | 5124.638 | 5124.648 | 2 1 1 | 3 3 0 | 11 | 18 |
| 65 | 5125.200 | 5125.200 | 1 1 1 | 2 2 0 | 110 | 18 |
| 66 | 5127.344 | 5127.344 | 5 1 5 | 5 2 4 | 110 | 18 |
| 67 | 5128.515 | 5128.515 | 7 4 3 | 8 4 4 | 11 | 18 |
| 68 | 5128.762 | 5128.763 | 6 2 5 | 6 3 4 | 110 | 18 |
| 69 | 5129.007 | 5129.004 | 6 3 4 | 6 4 3 | 110 | 18 |
| 70 | 5130.334 | 5130.334 | 7 3 5 | 8 3 6 | 11 | 18 |
| 71 | 5130.957 | 5130.957 | 3 0 3 | 4 2 2 | 11 | 18 |
| 72 | 5131.727 | 5131.730 | 3 0 3 | 4 1 4 | 110 | 18 |
| 73 | 5132.054 | 5132.065 | 1 1 0 | 2 2 1 | 110 | 18 |
| 73 | 5132.054 | 5132.042 | 8 6 2 | 9 6 3 | 11 | 18 |
| 74 | 5132.204N | 5132.187 | 8 6 3 | 9 6 4 | 11 | 18 |
| 74 | 5132.204N | 5132.205 | 7 1 6 | 8 1 7 | 11 | 18 |
| 75 | 5132.623 | 5132.625 | 5 3 3 | 5 4 2 | 110 | 18 |
| 76 | 5134.686 | 5134.686 | 7 4 4 | 8 4 5 | 11 | 18 |
| 77 | 5134.870 | 5134.869 | 4 3 2 | 4 4 1 | 110 | 18 |
| 78 | 5135.505N | 5135.507 | 7 2 6 | 8 2 7 | 11 | 18 |
| 79 | 5136.382N | 5136.380 | 6 2 4 | 7 2 5 | 11 | 18 |
| 80 | 5138.215 | 5138.212 | 5 3 2 | 5 4 1 | 110 | 18 |
| 81 | 5139.207 | 5139.213 | 5 2 4 | 5 3 3 | 110 | 18 |
| 82 | 5139.337 | 5139.336 | 6 3 3 | 7 3 4 | 11 | 18 |
| 83 | 5140.334 | 5140.338 | 7 1 6 | 7 2 5 | 110 | 18 |
| 84 | 5141.066 | 5141.064 | 3 1 3 | 4 0 4 | 110 | 18 |
| 85 | 5141.457 | 5141.456 | 5 0 5 | 5 1 4 | 110 | 18 |
| 86 | 5143.602N | 5143.603 | 7 0 7 | 8 0 8 | 11 | 18 |
| 87 | 5143.773N | 5143.773 | 7 1 7 | 8 1 8 | 11 | 18 |
| 88 | 5143.982 | | 8 7 1 | 9 7 2 | 11 | 18 |
| 88 | 5143.982 | | 8 7 2 | 9 7 3 | 11 | 18 |
| 88 | 5143.982 | 5143.975 | 4 1 4 | 4 2 3 | 110 | 18 |
| 89 | 5144.973 | 5144.971 | 7 5 2 | 8 5 3 | 11 | 18 |
| 90 | 5145.608 | 5145.607 | 7 5 3 | 8 5 4 | 11 | 18 |
| 91 | 5146.703 | 5146.703 | 4 2 3 | 4 3 2 | 110 | 18 |
| 92 | 5148.240 | 5148.235 | 4 2 2 | 4 4 1 | 11 | 18 |
| 93 | 5148.561 | 5148.562 | 2 0 2 | 3 1 3 | 110 | 18 |
| 94 | 5150.513N | 5150.512 | 6 1 5 | 7 1 6 | 11 | 18 |
| 95 | 5151.456 | 5151.456 | 3 2 2 | 3 3 1 | 110 | 18 |
| 96 | 5151.962 | | | | | |
| 97 | 5153.244 | 5153.244 | 6 3 4 | 7 3 5 | 11 | 18 |
| 98 | 5155.703 | | | | | |
| 99 | 5156.156N | 5156.158 | 6 2 5 | 7 2 6 | 11 | 18 |

foreoptics, source, and detector were housed in a vacuum box which was connected to the vacuum spectrometer and the absorption cell.

The $H_2{}^{18}O$ sample was supplied by the Bio-Rad Corp. The stated sample mixture ratio of $H_2{}^{18}O$ to $H_2{}^{16}O$ was 1-to-1 and the $H_2{}^{17}O$ impurity was 0.1% of the sample. The path lengths ranged from 8 to 48 m and the sample pressure and temperature were 2.3 Torr and 296 K, respectively. The $H_2{}^{18}O$ and $H_2{}^{17}O$ line positions were calibrated from the known $H_2{}^{16}O$ absorptions (*2*). The line strength measurements were made from spectra of $H_2{}^{16}O$ (*3*).

## DATA ANALYSIS

The identifications of the majority of the $H_2{}^{17}O$ absorptions were made by superimposing spectra of $H_2{}^{18}O/H_2{}^{16}O$ with those of $H_2{}^{16}O$ in which the optical density of

TABLE 3—*Continued*

| Line No. | Frequency ($CM^{-1}$) (Obs.) | (Calc.) | Upper State $JK_{-1}K_1$ | | | Lower State $JK_{-1}K_1$ | | | Band | Mol. |
|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 5156.248 | 5156.244 | 8 | 0 | 8 | 8 | 2 | 7 | 11 | 18 |
| 101 | 5157.282 | 5157.280 | 6 | 4 | 2 | 7 | 4 | 3 | 11 | 18 |
| 102 | 5157.539 | 5157.540 | 3 | 1 | 3 | 3 | 2 | 2 | 110 | 18 |
| 103 | 5157.789 | 5157.789 | 7 | 6 | 1 | 8 | 6 | 2 | 11 | 18 |
| 104 | 5157.823 | 5157.823 | 7 | 6 | 2 | 8 | 6 | 3 | 11 | 18 |
| 105 | 5158.775 | 5158.748 | 3 | 2 | 2 | 4 | 1 | 3 | 110 | 18 |
| 105 | 5158.775 | 5158.775 | 8 | 1 | 8 | 8 | 1 | 7 | 11 | 18 |
| 106 | 5159.901 | 5159.867 | 5 | 2 | 3 | 6 | 2 | 4 | 11 | 18 |
| 107 | 5160.121 | 5160.121 | 6 | 1 | 5 | 6 | 2 | 4 | 110 | 18 |
| 108 | 5161.215 | 5161.218 | 4 | 2 | 2 | 4 | 3 | 1 | 110 | 18 |
| 109 | 5162.230 | 5162.231 | 6 | 4 | 3 | 7 | 3 | 4 | 110 | 18 |
| 110 | 5164.061 | | 7 | 2 | 5 | 7 | 3 | 4 | 110 | 18 |
| 111 | 5164.240 | 5164.240 | 4 | 0 | 4 | 4 | 1 | 3 | 110 | 18 |
| 112 | 5164.748N | 5164.744 | 6 | 0 | 6 | 7 | 0 | 7 | 11 | 18 |
| 113 | 5164.879 | 5164.879 | 2 | 1 | 2 | 3 | 0 | 3 | 110 | 18 |
| 114 | 5165.140N | 5165.145 | 5 | 2 | 3 | 5 | 3 | 2 | 110 | 18 |
| 114 | 5165.140N | 5165.141 | 6 | 1 | 6 | 7 | 1 | 7 | 11 | 18 |
| 115 | 5165.642 | 5165.650 | 1 | 0 | 1 | 2 | 1 | 2 | 110 | 18 |
| 116 | 5165.796 | 5165.800 | 6 | 2 | 4 | 6 | 4 | 3 | 11 | 18 |
| 117 | 5166.915 | 5166.915 | 6 | 2 | 4 | 6 | 3 | 3 | 110 | 18 |
| 118 | 5167.737 | 5167.740 | 2 | 1 | 2 | 2 | 2 | 1 | 110 | 18 |
| 119 | 5168.793N | 5168.794 | 5 | 1 | 4 | 6 | 1 | 5 | 11 | 18 |
| 120 | 5168.908 | 5168.907 | 5 | 3 | 2 | 6 | 3 | 3 | 11 | 18 |
| 121 | 5168.969 | 5168.969 | 2 | 0 | 2 | 3 | 2 | 1 | 11 | 18 |
| 122 | 5169.373 | 5169.374 | 3 | 1 | 3 | 3 | 3 | 0 | 11 | 18 |
| 122 | 5169.373 | 5169.348 | 7 | 7 | 1 | 8 | 7 | 2 | 11 | 18 |
| 122 | 5169.373 | 5169.348 | 7 | 7 | 0 | 8 | 7 | 1 | 11 | 18 |
| 123 | 5171.137 | 5171.125 | 7 | 4 | 3 | 8 | 3 | 6 | 110 | 18 |
| 124 | 5171.230 | 5171.230 | 6 | 5 | 1 | 7 | 5 | 2 | 11 | 18 |
| 125 | 5171.407 | 5171.407 | 6 | 5 | 2 | 7 | 5 | 3 | 11 | 18 |
| 126 | 5172.354 | 5172.356 | 4 | 3 | 2 | 5 | 2 | 3 | 110 | 18 |
| 127 | 5174.137 | 5174.137 | 5 | 1 | 4 | 5 | 2 | 3 | 110 | 18 |
| 128 | 5174.196N | 5174.197 | 6 | 0 | 6 | 7 | 0 | 7 | 11 | 17 |
| 129 | 5174.608 | 5174.603 | 6 | 1 | 6 | 7 | 1 | 7 | 11 | 17 |
| 130 | 5177.073 | 5177.054 | 5 | 2 | 4 | 6 | 2 | 5 | 11 | 18 |
| 130 | 5177.073 | 5177.088 | 5 | 3 | 3 | 6 | 3 | 4 | 11 | 18 |
| 131 | 5177.924 | 5177.922 | 7 | 0 | 7 | 7 | 2 | 6 | 11 | 18 |
| 132 | 5178.471 | 5178.473 | 8 | 2 | 6 | 8 | 4 | 5 | 11 | 18 |
| 133 | 5179.941 | | 5 | 3 | 2 | 6 | 3 | 3 | 11 | 17 |
| 134 | 5182.017 | 5182.011 | 4 | 1 | 3 | 4 | [illegible] | 2 | 110 | 18 |
| 135 | 5182.674 | 5182.675 | 3 | 0 | 3 | 3 | [illegible] | 2 | 110 | 18 |
| 136 | 5183.073 | 5183.068 | 2 | 1 | 1 | 2 | 2 | 0 | 110 | 18 |
| 136 | 5183.073 | 5183.077 | 7 | 1 | 7 | 7 | 1 | 6 | 11 | 18 |
| 137 | 5183.300 | 5183.301 | 6 | 6 | 1 | 7 | 6 | 2 | 11 | 18 |
| 137 | 5183.300 | 5183.297 | 6 | 6 | 0 | 7 | 6 | 1 | 11 | 18 |
| 138 | 5184.341 | 5184.335 | 9 | 2 | 8 | 9 | 2 | 7 | 11 | 18 |
| 139 | 5184.494 | 5184.498 | 3 | 1 | 2 | 3 | 2 | 1 | 110 | 18 |
| 139 | 5184.494 | 5184.490 | 0 | 0 | 0 | 1 | 1 | 1 | 110 | 18 |
| 140 | 5184.655 | 5184.655 | 5 | 4 | 1 | 6 | 4 | 2 | 11 | 18 |
| 141 | 5185.245 | 5185.252 | 5 | 0 | 5 | 6 | 0 | 6 | 11 | 18 |
| 142 | 5185.570N | 5185.570 | 5 | 4 | 2 | 6 | 4 | 3 | 11 | 18 |
| 143 | 5185.721N | 5185.722 | 4 | 2 | 2 | 5 | 2 | 3 | 11 | 18 |
| 144 | 5186.115N | 5186.115 | 5 | 1 | 5 | 6 | 1 | 6 | 11 | 18 |
| 145 | 5186.210 | 5186.252 | 6 | 3 | 3 | 7 | 2 | 6 | 110 | 18 |
| 145 | 5186.210 | 5186.204 | 8 | 1 | 7 | 8 | 3 | 6 | 11 | 18 |
| 146 | 5186.385N | 5186.385 | 5 | 2 | 4 | 6 | 2 | 5 | 11 | 17 |
| 147 | 5186.715 | 5186.712 | 5 | 3 | 3 | 6 | 3 | 4 | 11 | 17 |

| Line No. | Frequency ($CM^{-1}$) (Obs.) | (Calc.) | Upper State $JK_{-1}K_1$ | | | Lower State $JK_{-1}K_1$ | | | Band | Mol. |
|---|---|---|---|---|---|---|---|---|---|---|
| 148 | 5188.375N | 5188.377 | 4 | 1 | 3 | 5 | 1 | 4 | 11 | 18 |
| 149 | 5188.785 | 5188.784 | 7 | 3 | 4 | 8 | 2 | 7 | 110 | 18 |
| 150 | 5190.055 | 5190.057 | 1 | 1 | 1 | 2 | 0 | 2 | 110 | 18 |
| 151 | 5192.552 | 5192.553 | 5 | 3 | 2 | 6 | 2 | 5 | 110 | 18 |
| 152 | 5194.759 | 5194.753 | 5 | 0 | 5 | 6 | 0 | 6 | 11 | 17 |
| 153 | 5195.341 | 5195.296 | 5 | 4 | 2 | 6 | 4 | 3 | 11 | 17 |
| 153 | 5195.341 | 5195.341 | 2 | 0 | 2 | 2 | 1 | 1 | 110 | 18 |
| 154 | 5195.501N | 5195.502 | 4 | 2 | 2 | 5 | 2 | 3 | 11 | 17 |
| 155 | 5195.619N | 5195.616 | 5 | 1 | 5 | 6 | 1 | 6 | 11 | 17 |
| 156 | 5196.985 | 5196.989 | 5 | 5 | 0 | 6 | 5 | 1 | 11 | 18 |
| 157 | 5197.024 | 5197.024 | 5 | 5 | 1 | 6 | 5 | 2 | 11 | 18 |
| 158 | 5197.934N | 5197.999 | 4 | 1 | 3 | 5 | 1 | 4 | 11 | 17 |
| 158 | 5197.934N | 5197.934 | 4 | 3 | 1 | 5 | 3 | 2 | 11 | 18 |
| 159 | 5198.069 | 5198.073 | 6 | 0 | 6 | 6 | 2 | 5 | 11 | 18 |
| 160 | 5198.469 | 5198.472 | 4 | 3 | 1 | 5 | 2 | 4 | 110 | 18 |
| 161 | 5198.932 | 5198.932 | 7 | 1 | 6 | 7 | 3 | 5 | 11 | 18 |
| 162 | 5199.235 | 5199.238 | 1 | 0 | 1 | 2 | 2 | 0 | 11 | 18 |
| 163 | 5201.675N | 5201.675 | 4 | 3 | 2 | 5 | 3 | 3 | 11 | 18 |
| 164 | 5202.619 | 5202.616 | 1 | 0 | 1 | 1 | 1 | 0 | 110 | 18 |
| 165 | 5202.878 | 5202.886 | 3 | 1 | 2 | 3 | 3 | 1 | 11 | 18 |
| 166 | 5205.039N | 5205.040 | 4 | 0 | 4 | 5 | 0 | 5 | 11 | 18 |
| 167 | 5206.367 | 5206.382 | 4 | 2 | 3 | 5 | 2 | 4 | 11 | 18 |
| 168 | 5206.655 | 5206.654 | 4 | 1 | 4 | 5 | 1 | 5 | 11 | 18 |
| 169 | 5206.827 | | 5 | 5 | 1 | 6 | 5 | 2 | 11 | 17 |
| 169 | 5206.827 | 5206.822 | 6 | 1 | 5 | 6 | 3 | 4 | 11 | 18 |
| 170 | 5207.222 | 5207.220 | 3 | 3 | 1 | 4 | 2 | 2 | 110 | 18 |
| 171 | 5207.448 | 5207.447 | 4 | 1 | 3 | 4 | 3 | 2 | 11 | 18 |
| 172 | 5207.520 | 5207.520 | 4 | 3 | 1 | 5 | 2 | 4 | 110 | 17 |
| 173 | 5207.747 | 5207.740 | 4 | 3 | 1 | 5 | 3 | 2 | 11 | 17 |
| 174 | 5207.949 | 5207.947 | 6 | 1 | 6 | 6 | 1 | 5 | 11 | 18 |
| 175 | 5209.377 | 5209.376 | 5 | 1 | 4 | 5 | 3 | 3 | 11 | 18 |
| 176 | 5210.178N | 5210.178 | 3 | 1 | 2 | 4 | 1 | 3 | 11 | 18 |
| 177 | 5210.587 | 5210.591 | 8 | 2 | 7 | 8 | 2 | 6 | 11 | 18 |
| 178 | 5210.943N | 5210.943 | 4 | 4 | 0 | 5 | 4 | 1 | 11 | 18 |
| 179 | 5211.165 | 5211.165 | 4 | 4 | 1 | 5 | 4 | 2 | 11 | 18 |
| 180 | 5211.379 | 5211.380 | 4 | 3 | 2 | 5 | 3 | 3 | 11 | 17 |
| 181 | 5211.708 | 5211.708 | 5 | 4 | 1 | 6 | 3 | 4 | 110 | 18 |
| 182 | 5213.265N | 5213.265 | 3 | 2 | 1 | 4 | 2 | 2 | 11 | 18 |
| 183 | 5214.582N | 5214.584 | 4 | 0 | 4 | 5 | 0 | 5 | 11 | 17 |
| 184 | 5215.427 | 5215.428 | 3 | 2 | 1 | 4 | 1 | 4 | 110 | 18 |
| 185 | 5215.617 | 5215.617 | 4 | 1 | 4 | 5 | 1 | 5 | 11 | 17 |
| 186 | 5215.936 | 5215.935 | 5 | 0 | 5 | 5 | 2 | 4 | 11 | 18 |
| 187 | 5216.704 | 5216.705 | 4 | 2 | 2 | 5 | 1 | 5 | 110 | 18 |
| 188 | 5219.886N | 5219.891 | 3 | 1 | 2 | 4 | 1 | 3 | 11 | 17 |
| 189 | 5220.916N | 5220.917 | 3 | 3 | 0 | 4 | 2 | 3 | 110 | 18 |
| 190 | 5222.952 | 5222.950 | 3 | 2 | 1 | 4 | 2 | 2 | 11 | 17 |
| 191 | 5224.184N | 5224.184 | 3 | 0 | 3 | 4 | 0 | 4 | 11 | 18 |
| 192 | 5225.195 | 5225.196 | 3 | 2 | 2 | 4 | 2 | 3 | 11 | 18 |
| 193 | 5225.491 | 5225.490 | 3 | 3 | 0 | 4 | 3 | 1 | 11 | 18 |
| 194 | 5226.690N | 5226.690 | 3 | 3 | 1 | 4 | 3 | 2 | 11 | 18 |
| 195 | 5227.851 | 5227.851 | 3 | 1 | 3 | 4 | 1 | 4 | 11 | 18 |
| 196 | 5229.495 | 5229.493 | 3 | 3 | 0 | 4 | 2 | 3 | 110 | 17 |
| 197 | 5230.202 | | | | | | | | | |
| 198 | 5230.466N | 5230.466 | 4 | 0 | 4 | 4 | 2 | 3 | 11 | 18 |
| 199 | 5233.101N | 5233.100 | 5 | 1 | 5 | 5 | 1 | 4 | 11 | 18 |
| 200 | 5233.653N | 5233.651 | 3 | 2 | 2 | 4 | 2 | 3 | 11 | 17 |
| 201 | 5233.780 | 5233.783 | 3 | 0 | 3 | 4 | 0 | 4 | 11 | 17 |

$H_2{}^{17}O$ was identical in the two spectra. Therefore in comparing the two sets of spectra the peak absorptions of $H_2{}^{16}O$ lines were much smaller in the $H_2{}^{18}O/H_2{}^{16}O$ data than in the $H_2{}^{16}O$ spectra, while the opposite effect was observed for the $H_2{}^{18}O$ lines. The quantum assignments of the measured $H_2{}^{18}O$ lines were determined by noting that: (a) the frequency difference between identical transitions of $H_2{}^{16}O$ and $H_2{}^{18}O$ are approximately 20 and 10 $cm^{-1}$ for the (011) and (110) bands, respectively, and (b) the peak absorptions for identical transitions in $H_2{}^{16}O$ and $H_2{}^{18}O$ were approximately equal in the $H_2{}^{18}O/H_2{}^{16}O$ spectra. The $H_2{}^{17}O$ assignments were obtained by noting that their transition frequencies lie in a region midway between the positions of identical transitions in $H_2{}^{16}O$ and $H_2{}^{18}O$.

TABLE 3—*Continued*

| Line No. | Frequency ($CM^{-1}$) (Obs.) | Frequency ($CM^{-1}$) (Calc.) | Upper State $JK_{-1}K_1$ | Lower State $JK_{-1}K_1$ | Band | Mol. |
|---|---|---|---|---|---|---|
| 202 | 5234.070N | 5234.070 | 2 1 1 | 3 1 2 | 11 | 18 |
| 203 | 5236.447N | 5236.447 | 3 3 1 | 4 3 2 | 11 | 17 |
| 204 | 5236.967 | 5236.968 | 7 2 6 | 7 2 5 | 11 | 18 |
| 205 | 5237.471N | 5237.472 | 3 1 3 | 4 1 4 | 11 | 17 |
| 206 | 5240.645N | 5240.660 | 3 0 3 | 3 2 2 | 11 | 18 |
| 206 | 5240.645N | 5240.642 | 2 2 0 | 3 2 1 | 11 | 18 |
| 207 | 5241.786 | 5241.786 | 1 1 0 | 1 0 1 | 110 | 18 |
| 208 | 5243.431N | 5243.431 | 2 0 2 | 3 0 3 | 11 | 18 |
| 209 | 5245.345N | 5245.345 | 2 2 1 | 3 2 2 | 11 | 18 |
| 210 | 5247.925 | 5247.925 | 2 1 1 | 2 0 2 | 110 | 18 |
| 211 | 5248.536N | 5248.535 | 2 1 2 | 3 1 3 | 11 | 18 |
| 212 | 5250.456N | 5250.454 | 2 2 0 | 3 2 1 | 11 | 17 |
| 213 | 5253.097N | 5253.097 | 2 0 2 | 3 0 3 | 11 | 17 |
| 214 | 5253.380 | 5253.380 | 2 0 2 | 1 1 1 | 110 | 18 |
| 215 | 5255.089 | 5255.091 | 2 2 1 | 3 2 2 | 11 | 17 |
| 216 | 5257.066 | 5257.067 | 4 1 4 | 4 1 3 | 11 | 18 |
| 217 | 5258.222 | 5258.222 | 2 1 2 | 3 1 3 | 11 | 17 |
| 217 | 5258.222 | 5258.210 | 6 2 5 | 5 4 2 | 11 | 18 |
| 218 | 5258.960 | 5258.960 | 3 1 2 | 3 0 3 | 110 | 18 |
| 219 | 5259.410N | 5259.412 | 1 1 0 | 2 1 1 | 11 | 18 |
| 220 | 5259.986 | 5259.985 | 1 1 1 | 0 0 0 | 110 | 18 |
| 221 | 5261.829 | 5261.821 | 3 1 2 | 2 2 1 | 110 | 18 |
| 222 | 5264.096N | 5264.095 | 1 0 1 | 2 0 2 | 11 | 18 |
| 223 | 5266.372 | 5266.381 | 4 1 4 | 4 1 3 | 11 | 17 |
| 223 | 5266.372 | 5266.373 | 3 2 1 | 3 1 2 | 110 | 18 |
| 224 | 5267.124 | 5267.118 | 4 2 2 | 4 1 3 | 110 | 18 |
| 225 | 5269.578N | 5269.578 | 1 1 1 | 2 1 2 | 11 | 18 |
| 226 | 5269.818 | 5269.817 | 2 2 0 | 2 1 1 | 110 | 18 |
| 227 | 5272.278 | 5272.275 | 8 3 6 | 8 3 5 | 11 | 18 |
| 228 | 5272.514 | 5272.514 | 5 2 3 | 5 1 4 | 110 | 18 |
| 229 | 5273.823 | 5273.824 | 1 0 1 | 2 0 2 | 11 | 17 |
| 230 | 5275.232 | 5275.238 | 4 1 3 | 4 0 4 | 110 | 18 |
| 231 | 5276.575 | 5276.569 | 3 0 3 | 2 1 2 | 110 | 18 |
| 232 | 5277.190 | 5277.196 | 6 3 3 | 7 1 6 | 11 | 18 |
| 233 | 5278.796N | 5278.796 | 3 1 3 | 3 1 2 | 11 | 18 |
| 234 | 5279.312N | 5279.311 | 1 1 1 | 2 1 2 | 11 | 17 |
| 235 | 5284.382 | 5284.345 | 6 2 4 | 6 1 5 | 110 | 18 |
| 235 | 5284.382 | 5284.380 | 2 2 1 | 2 1 2 | 110 | 18 |
| 236 | 5286.712 | 5286.712 | 0 0 0 | 1 0 1 | 11 | 18 |
| 237 | 5288.664N | 5288.670 | 3 1 3 | 3 1 2 | 11 | 17 |
| 238 | 5290.199 | 5290.245 | 7 3 4 | 7 2 5 | 110 | 18 |
| 239 | 5291.611 | 5291.613 | 6 3 3 | 6 2 4 | 110 | 18 |
| 239 | 5291.611 | 5291.584 | 5 2 3 | 4 3 2 | 110 | 18 |
| 240 | 5292.372 | 5292.370 | 3 1 3 | 2 0 2 | 110 | 18 |
| 241 | 5292.488 | 5292.490 | 7 3 5 | 7 3 4 | 11 | 18 |
| 242 | 5295.250 | 5295.249 | 5 1 4 | 5 0 5 | 110 | 18 |
| 243 | 5295.314N | 5295.314 | 2 1 2 | 2 1 1 | 11 | 18 |
| 244 | 5296.487 | 5296.487 | 0 0 0 | 1 0 1 | 11 | 17 |
| 245 | 5297.476 | 5297.475 | 4 0 4 | 3 1 3 | 110 | 18 |
| 246 | 5297.848 | 5297.847 | 5 3 2 | 5 2 3 | 110 | 18 |
| 247 | 5298.182 | 5298.181 | 4 3 1 | 4 2 2 | 110 | 18 |
| 248 | 5302.165 | 5302.165 | 4 2 3 | 4 1 4 | 110 | 18 |
| 249 | 5305.314 | 5305.303 | 4 3 1 | 5 1 4 | 11 | 18 |
| 249 | 5305.314 | 5305.335 | 9 4 6 | 9 4 5 | 11 | 18 |
| 250 | 5306.092 | 5306.091 | 4 2 3 | 4 2 2 | 11 | 18 |
| 251 | 5306.259 | 5306.258 | 4 1 4 | 3 0 3 | 110 | 18 |
| 252 | 5306.544N | 5306.544 | 1 1 1 | 1 1 0 | 11 | 18 |
| 253 | 5306.836 | 5306.834 | 4 2 2 | 5 0 5 | 11 | 18 |
| 254 | 5307.397 | 5307.401 | 6 3 4 | 6 3 3 | 11 | 18 |
| 255 | 5308.381 | | | | | |
| 256 | 5308.739 | 5308.738 | 3 3 0 | 3 2 1 | 110 | 18 |
| 257 | 5310.631 | 5310.633 | 3 0 3 | 2 2 0 | 11 | 18 |
| 258 | 5313.017N | 5313.017 | 3 2 2 | 3 2 1 | 11 | 18 |
| 259 | 5315.104 | 5315.104 | 2 2 0 | 3 0 3 | 11 | 18 |
| 260 | 5315.318N | 5315.318 | 2 2 1 | 2 2 0 | 11 | 18 |
| 261 | 5315.990 | 5315.988 | 5 0 5 | 4 1 4 | 110 | 18 |
| 262 | 5316.356 | 5316.357 | 1 1 1 | 1 1 0 | 11 | 17 |
| 263 | 5316.743 | 5316.743 | 5 3 3 | 5 3 2 | 11 | 18 |
| 264 | 5316.921 | 5316.923 | 3 3 1 | 3 2 2 | 110 | 18 |
| 265 | 5317.453N | 5317.492 | 3 3 0 | 3 2 1 | 110 | 17 |
| 265 | 5317.453N | 5317.451 | 1 1 0 | 1 1 1 | 11 | 18 |
| 266 | 5317.974 | 5318.018 | 8 4 5 | 8 4 4 | 11 | 18 |
| 266 | 5317.974 | 5317.965 | 2 2 0 | 2 2 1 | 11 | 18 |
| 267 | 5318.287 | 5318.287 | 4 0 4 | 3 2 1 | 11 | 18 |
| 268 | 5318.893 | 5318.894 | 4 3 2 | 4 2 3 | 110 | 18 |
| 269 | 5320.280 | 5320.280 | 5 1 5 | 4 0 4 | 110 | 18 |
| 270 | 5320.684 | 5320.675 | 5 1 4 | 4 2 3 | 110 | 18 |
| 271 | 5321.344 | 5321.346 | 2 2 1 | 1 1 0 | 110 | 18 |
| 272 | 5321.570N | 5321.569 | 4 3 2 | 4 3 1 | 11 | 18 |
| 273 | 5321.645 | 5321.650 | 3 2 2 | 3 2 1 | 11 | 17 |
| 274 | 5322.968N | 5323.002 | 5 3 3 | 5 2 4 | 110 | 18 |
| 274 | 5322.968N | 5322.968 | 3 2 1 | 3 2 2 | 11 | 18 |
| 275 | 5323.674N | 5323.675 | 3 3 1 | 3 3 0 | 11 | 18 |
| 276 | 5324.097N | 5324.098 | 3 3 0 | 3 3 1 | 11 | 18 |
| 277 | 5324.373N | 5324.373 | 4 3 1 | 4 3 2 | 11 | 18 |
| 278 | 5325.145 | 5325.143 | 2 2 1 | 2 2 0 | 11 | 17 |
| 279 | 5325.622 | 5325.621 | 7 4 4 | 7 4 3 | 11 | 18 |
| 280 | 5326.919 | 5326.919 | 5 3 2 | 5 3 3 | 11 | 18 |
| 281 | 5327.214 | 5327.214 | 1 1 0 | 1 1 1 | 11 | 17 |
| 282 | 5327.747N | 5327.748 | 2 2 0 | 2 2 1 | 11 | 17 |
| 283 | 5327.857 | 5327.856 | 2 2 0 | 1 1 1 | 110 | 18 |
| 284 | 5327.964 | 5327.964 | 2 1 1 | 2 1 2 | 11 | 18 |
| 285 | 5328.800 | 5328.802 | 6 2 5 | 6 1 6 | 110 | 18 |
| 286 | 5329.691N | 5329.690 | 6 4 3 | 6 4 2 | 11 | 18 |
| 287 | 5331.380 | 5331.380 | 4 3 2 | 4 3 1 | 11 | 17 |
| 287 | 5331.380 | 5331.390 | 3 3 0 | 4 1 3 | 11 | 18 |
| 288 | 5331.812N | 5331.812 | 5 4 2 | 5 4 1 | 11 | 18 |
| 289 | 5331.947 | 5331.948 | 6 4 2 | 6 4 3 | 11 | 18 |
| 290 | 5332.270 | 5332.299 | 5 4 1 | 5 4 2 | 11 | 18 |
| 290 | 5332.270 | 5332.260 | 4 2 2 | 4 2 3 | 11 | 18 |
| 291 | 5332.540 | 5332.541 | 3 2 1 | 3 2 2 | 11 | 17 |
| 292 | 5332.666 | 5332.667 | 6 0 6 | 5 1 5 | 110 | 18 |
| 293 | 5333.064 | 5333.036 | 4 4 1 | 4 4 0 | 11 | 16 |
| 293 | 5333.064 | 5333.091 | 4 4 0 | 4 4 1 | 11 | 18 |
| 293 | 5333.064 | 5333.058 | 7 4 3 | 7 4 4 | 11 | 18 |
| 294 | 5333.280 | 5333.281 | 7 4 3 | 7 3 4 | 110 | 18 |
| 295 | 5333.500 | 5333.485 | 3 3 1 | 3 3 0 | 11 | 17 |
| 295 | 5333.500 | 5333.506 | 6 3 3 | 6 3 4 | 11 | 18 |
| 296 | 5333.897N | 5333.897 | 3 3 0 | 3 3 1 | 11 | 17 |
| 297 | 5334.024 | 5334.023 | 1 0 1 | 0 0 0 | 11 | 18 |
| 298 | 5334.107N | 5334.110 | 4 3 1 | 4 3 2 | 11 | 17 |
| 299 | 5334.622 | 5334.614 | 6 1 6 | 5 0 5 | 110 | 18 |
| 300 | 5334.974 | 5334.976 | 9 5 5 | 9 5 4 | 11 | 18 |
| 301 | 5337.199 | 5337.198 | 8 4 4 | 8 4 5 | 11 | 18 |

The $H_2{}^{18}O$ line strength measurements were made from previously recorded spectra of $H_2{}^{16}O$ (*3*) in which only the strongest lines of $H_2{}^{18}O$ were observed. The line strengths were determined by the method of equivalent widths. The procedure for determining line strengths of water vapor from the equivalent widths has been discussed in detail in earlier reports (*3, 4*).

## RESULTS

Values of the ground state levels of $H_2{}^{18}O$ and $H_2{}^{17}O$ are presented in Table 1. The Table lists the rotational quantum numbers ($JK_{-1}K_1$) and three sets of values for $H_2{}^{18}O$

TABLE 3—*Continued*

| Line No. | Frequency ($CM^{-1}$) (Obs.) | Frequency ($CM^{-1}$) (Calc.) | Upper State $JK_{-1}K_1$ | Lower State $JK_{-1}K_1$ | Band | Mol. |
|---|---|---|---|---|---|---|
| 302 | 5339.242 | | | | | |
| 303 | 5340.181 | 5340.179 | 8 5 3 | 8 5 4 | 11 | 18 |
| 304 | 5340.776 | 5340.780 | 7 5 3 | 7 5 2 | 11 | 18 |
| 305 | 5341.186 | 5341.187 | 7 5 2 | 7 5 3 | 11 | 18 |
| 306 | 5341.606N | 5341.607 | 5 4 2 | 5 4 1 | 11 | 17 |
| 307 | 5341.854N | 5341.855 | 4 2 2 | 4 2 3 | 11 | 17 |
| 308 | 5342.286 | 5342.286 | 6 5 2 | 6 5 1 | 11 | 18 |
| 309 | 5342.371 | 5342.357 | 6 5 1 | 6 5 2 | 11 | 18 |
| 310 | 5342.893N | 5342.880 | 4 4 1 | 4 4 0 | 11 | 17 |
| 310 | 5342.893N | 5342.902 | 4 4 0 | 4 4 1 | 11 | 17 |
| 311 | 5343.695 | 5343.695 | 6 4 2 | 6 3 3 | 110 | 18 |
| 312 | 5343.834N | 5343.834 | 1 0 1 | 0 0 0 | 11 | 17 |
| 313 | 5344.596 | 5344.604 | 7 3 4 | 7 3 5 | 11 | 18 |
| 314 | 5346.483 | 5346.477 | 6 1 5 | 5 3 2 | 11 | 18 |
| 315 | 5346.955 | 5346.955 | 5 2 3 | 5 2 4 | 11 | 18 |
| 316 | 5347.175 | 5347.189 | 6 1 5 | 5 2 4 | 110 | 18 |
| 317 | 5348.070 | 5348.066 | 7 0 7 | 6 1 6 | 110 | 18 |
| 318 | 5348.891 | 5348.895 | 7 1 7 | 6 0 6 | 110 | 18 |
| 319 | 5349.775 | 5349.776 | 9 6 4 | 9 6 3 | 11 | 18 |
| 320 | 5351.362 | 5351.363 | 5 4 1 | 5 3 2 | 110 | 18 |
| 321 | 5351.611 | | | | | |
| 322 | 5351.681 | 5351.626 | 8 6 3 | 8 6 2 | 11 | 18 |
| 322 | 5351.681 | 5351.676 | 8 6 2 | 8 6 3 | 11 | 18 |
| 323 | 5353.352 | 5353.353 | 2 1 2 | 1 1 1 | 11 | 18 |
| 324 | 5354.277 | 5354.276 | 6 6 1 | 6 6 0 | 11 | 18 |
| 324 | 5354.277 | 5354.279 | 6 6 0 | 6 6 1 | 11 | 18 |
| 325 | 5355.489 | 5355.474 | 8 4 5 | 8 3 6 | 110 | 18 |
| 326 | 5355.751 | 5355.757 | 4 4 0 | 4 3 1 | 110 | 18 |
| 327 | 5356.013N | 5356.013 | 2 0 2 | 1 0 1 | 11 | 18 |
| 328 | 5356.398 | 5356.401 | 6 4 3 | 6 3 4 | 110 | 18 |
| 328 | 5356.398 | 5356.366 | 5 4 2 | 5 3 3 | 110 | 18 |
| 329 | 5357.260 | | | | | |
| 330 | 5358.800 | 5358.799 | 7 4 4 | 7 3 5 | 110 | 18 |
| 331 | 5360.268 | 5360.267 | 3 2 1 | 2 1 2 | 110 | 18 |
| 332 | 5362.262 | | 9 7 3 | 9 7 2 | 11 | 18 |
| 333 | 5362.831 | 5362.828 | 8 1 8 | 7 0 7 | 110 | 18 |
| 334 | 5362.908N | 5362.909 | 4 1 3 | 4 1 4 | 11 | 18 |
| 335 | 5363.712 | 5363.712 | 8 7 2 | 8 7 1 | 11 | 18 |
| 335 | 5363.712 | 5363.712 | 8 7 1 | 8 7 2 | 11 | 18 |
| 336 | 5364.930N | 5364.930 | 2 1 1 | 1 1 0 | 11 | 18 |
| 337 | 5365.011 | 5365.036 | 7 7 0 | 7 7 1 | 11 | 18 |
| 337 | 5365.011 | 5365.036 | 7 7 1 | 7 7 0 | 11 | 18 |
| 337 | 5365.011 | 5365.007 | 5 2 4 | 4 1 3 | 110 | 18 |
| 338 | 5365.862N | 5365.862 | 2 0 2 | 1 0 1 | 11 | 17 |
| 339 | 5366.384N | 5366.383 | 6 2 4 | 6 2 5 | 11 | 18 |
| 340 | 5368.800 | 5368.802 | 8 3 5 | 8 3 6 | 11 | 18 |
| 341 | 5370.345 | 5370.341 | 7 1 6 | 6 2 5 | 110 | 18 |
| 342 | 5372.568 | 5372.568 | 4 1 3 | 4 1 4 | 11 | 17 |
| 343 | 5372.690N | 5372.690 | 3 1 3 | 2 1 2 | 11 | 18 |
| 344 | 5374.589 | | 8 8 1 | 8 8 0 | 11 | 18 |
| 344 | 5374.589 | | 8 8 0 | 8 8 1 | 11 | 18 |
| 345 | 5374.751N | 5374.751 | 2 1 1 | 1 1 0 | 11 | 17 |
| 346 | 5375.491N | 5375.490 | 3 0 3 | 2 0 2 | 11 | 18 |
| 347 | 5375.788 | 5375.787 | 6 2 5 | 5 1 4 | 110 | 18 |
| 348 | 5376.090 | 5376.090 | 9 0 9 | 8 1 8 | 110 | 18 |
| 349 | 5376.304 | 5376.304 | 9 1 9 | 8 0 8 | 110 | 18 |
| 350 | 5380.175 | 5380.175 | 2 2 1 | 2 0 2 | 11 | 18 |
| 351 | 5382.068 | | | | | |
| 352 | 5382.547N | 5382.541 | 3 1 3 | 2 1 2 | 11 | 17 |
| 353 | 5383.201 | 5383.200 | 3 3 0 | 3 0 3 | 110 | 18 |
| 354 | 5384.757 | 5384.757 | 5 1 4 | 5 1 5 | 11 | 18 |
| 355 | 5385.399N | 5385.396 | 3 0 3 | 2 0 2 | 11 | 17 |
| 356 | 5386.060N | 5386.061 | 3 3 0 | 2 2 1 | 110 | 18 |
| 357 | 5386.899 | 5386.896 | 3 3 1 | 2 2 0 | 110 | 18 |
| 358 | 5387.481N | 5387.479 | 3 2 2 | 3 0 3 | 11 | 18 |
| 359 | 5389.118 | 5389.119 | 7 2 5 | 7 2 6 | 11 | 18 |
| 360 | 5389.180 | 5389.182 | 10 1 10 | 9 0 9 | 110 | 18 |
| 361 | 5390.192N | 5390.192 | 3 1 2 | 2 1 1 | 11 | 18 |
| 362 | 5390.302N | 5390.340 | 3 2 2 | 2 2 1 | 11 | 18 |
| 362 | 5390.302N | 5390.302 | 4 1 4 | 3 1 3 | 11 | 18 |
| 363 | 5391.410 | 5391.408 | 4 3 1 | 4 0 4 | 110 | 18 |
| 364 | 5392.749N | 5392.749 | 4 0 4 | 3 0 3 | 11 | 18 |
| 365 | 5392.941N | 5392.941 | 3 2 1 | 2 2 0 | 11 | 18 |
| 366 | 5394.500 | | | | | |
| 367 | 5394.785N | 5394.786 | 3 3 0 | 2 2 1 | 110 | 17 |
| 368 | 5396.695 | | | | | |
| 369 | 5398.389 | | | | | |
| 370 | 5398.466 | | | | | |
| 371 | 5398.945N | 5398.944 | 3 2 2 | 2 2 1 | 11 | 17 |
| 372 | 5399.050 | | | | | |
| 373 | 5399.320 | 5399.318 | 4 2 3 | 4 0 4 | 11 | 18 |
| 374 | 5400.038N | 5400.034 | 3 1 2 | 2 1 1 | 11 | 17 |
| 375 | 5400.358 | 5400.353 | 4 2 2 | 3 1 3 | 110 | 18 |
| 376 | 5401.399 | | | | | |
| 377 | 5402.593 | 5402.593 | 3 2 1 | 2 2 0 | 11 | 17 |
| 378 | 5402.705N | 5402.704 | 4 0 4 | 3 0 3 | 11 | 17 |
| 379 | 5402.928 | | | | | |
| 380 | 5403.282 | | | | | |
| 381 | 5403.461N | 5403.460 | 5 2 4 | 5 0 5 | 11 | 18 |
| 382 | 5404.450 | | | | | |
| 383 | 5406.716N | 5406.715 | 4 3 2 | 3 2 1 | 110 | 18 |
| 384 | 5406.860 | 5406.861 | 6 1 5 | 6 1 6 | 11 | 18 |
| 385 | 5407.632N | 5407.632 | 5 1 5 | 4 1 4 | 11 | 18 |
| 386 | 5407.885N | 5407.884 | 4 3 1 | 3 2 2 | 110 | 18 |
| 387 | 5408.312 | | | | | |
| 388 | 5408.871N | 5408.871 | 5 0 5 | 4 0 4 | 11 | 18 |
| 389 | 5413.195 | 5413.147 | 10 3 7 | 10 3 8 | 11 | 18 |
| 389 | 5413.195 | 5413.195 | 8 2 6 | 8 2 7 | 11 | 18 |
| 390 | 5413.850 | 5413.854 | 4 1 3 | 3 1 2 | 11 | 18 |
| 391 | 5414.092 | | | | | |
| 392 | 5415.792 | 5415.794 | 4 2 3 | 3 2 2 | 11 | 18 |
| 393 | 5417.143N | 5417.167 | 4 3 1 | 3 2 2 | 110 | 17 |
| 393 | 5417.143N | | 6 1 5 | 6 1 6 | 11 | 17 |
| 394 | 5417.559N | 5417.561 | 5 1 5 | 4 1 4 | 11 | 17 |
| 395 | 5417.904 | 5417.904 | 6 2 5 | 6 0 6 | 11 | 18 |
| 396 | 5418.853N | 5418.859 | 5 0 5 | 4 0 4 | 11 | 17 |
| 397 | 5418.956 | 5418.959 | 5 3 2 | 5 0 5 | 110 | 18 |
| 398 | 5420.080N | 5420.081 | 4 2 2 | 3 2 1 | 11 | 18 |
| 399 | 5420.177N | 5420.177 | 4 3 2 | 3 3 1 | 11 | 18 |
| 400 | 5421.357N | 5421.358 | 4 3 1 | 3 3 0 | 11 | 18 |
| 401 | 5422.712 | 5422.711 | 5 3 3 | 4 2 2 | 110 | 18 |
| 402 | 5423.766N | 5423.766 | 4 1 3 | 3 1 2 | 11 | 17 |
| 402 | 5423.766N | 5423.766 | 4 2 3 | 3 2 2 | 11 | 17 |
| 403 | 5423.908N | 5423.910 | 6 1 6 | 5 1 5 | 11 | 18 |

and two sets for $H_2{}^{17}O$. The three sets of $H_2{}^{18}O$ values are from (a) the present work, (b) those given by Garing and McClatchey (*5*), and (c) the values obtained in an analysis of the (020) band by Toth and Margolis (*1*). The $H_2{}^{17}O$ levels are from (a) the present study and (b) Garing and McClatchey (*5*). Values given for this work were determined by the method of combination differences using the measured transition frequencies in the (011) and (110) bands for $H_2{}^{18}O$ and in the (011) band for $H_2{}^{17}O$. This procedure requires that values of the levels (101), (110), (111), are known from other sources or they are derived from the measured positions by obtaining an initial set of upper state levels and iterating between upper and lower state levels.

TABLE 3—*Continued*

| Line No. | Frequency ($CM^{-1}$) (Obs.) | Frequency ($CM^{-1}$) (Calc.) | Upper State $JK_{-1}K_1$ | Lower State $JK_{-1}K_1$ | Band | Mol. |
|---|---|---|---|---|---|---|
| 404 | 5424.111 | 5424.112 | 5 3 3 | 5 1 4 | 11 | 18 |
| 405 | 5424.479N | 5424.479. | 6 0 6 | 5 0 5 | 11 | 18 |
| 406 | 5424.833 | 5424.831 | 6 3 4 | 6 1 5 | 11 | 18 |
| 407 | 5427.698 | 5427.713 | 7 1 6 | 7 1 7 | 11 | 18 |
| 407 | 5427.698 | 5427.686 | 2 2 0 | 1 0 1 | 11 | 18 |
| 408 | 5428.886 | 5428.886 | 5 2 4 | 4 2 3 | 11 | 18 |
| 409 | 5429.858 | 5429.854 | 4 2 2 | 3 2 1 | 11 | 17 |
| 410 | 5429.980 | 5429.990 | 4 3 2 | 3 3 1 | 11 | 17 |
| 411 | 5430.353 | 5430.350 | 7 3 5 | 7 1 6 | 11 | 18 |
| 412 | 5431.145N | 5431.148 | 4 3 1 | 3 3 0 | 11 | 17 |
| 413 | 5433.643 | 5433.642 | 7 2 6 | 7 0 7 | 11 | 18 |
| 414 | 5433.875 | 5433.880 | 6 1 6 | 5 1 5 | 11 | 17 |
| 415 | 5434.475N | 5434.474 | 6 0 6 | 5 0 5 | 11 | 17 |
| 416 | 5435.171 | 5435.170 | 5 1 4 | 4 1 3 | 11 | 18 |
| 417 | 5438.556N | 5438.556 | 5 2 4 | 4 2 3 | 11 | 17 |
| 418 | 5439.426N | 5439.426 | 7 1 7 | 6 1 6 | 11 | 18 |
| 419 | 5439.669N | 5439.668 | 7 0 7 | 6 0 6 | 11 | 18 |
| 420 | 5440.118 | 5440.113 | 8 3 6 | 8 1 7 | 11 | 18 |
| 421 | 5443.182N | 5443.182 | 5 3 3 | 4 3 2 | 11 | 18 |
| 422 | 5444.069 | | | | | |
| 423 | 5444.384 | 5444.385 | 5 3 2 | 4 2 3 | 110 | 18 |
| 424 | 5446.663N | 5446.664 | 5 2 3 | 4 2 2 | 11 | 18 |
| 425 | 5446.812N | 5446.813 | 5 3 2 | 4 3 1 | 11 | 18 |
| 426 | 5446.916 | 5446.916 | 8 1 7 | 8 1 8 | 11 | 18 |
| 427 | 5448.588 | 5448.587 | 6 2 5 | 5 2 4 | 11 | 18 |
| 428 | 5449.401 | 5449.401 | 7 1 7 | 6 1 6 | 11 | 17 |
| 428 | 5449.401 | | 8 3 6 | 7 2 5 | 110 | 18 |
| 429 | 5449.667 | 5449.667 | 7 0 7 | 6 0 6 | 11 | 17 |
| 430 | 5451.546 | | | | | |
| 431 | 5451.749 | 5451.753 | 3 3 1 | 2 0 2 | 110 | 18 |
| 432 | 5452.824 | 5452.828 | 9 3 7 | 9 1 8 | 11 | 18 |
| 433 | 5452.978 | 5452.980 | 5 3 3 | 4 3 2 | 11 | 17 |
| 434 | 5453.846 | 5453.846 | 6 1 5 | 5 1 4 | 11 | 18 |
| 435 | 5453.959 | 5453.960 | 5 4 2 | 4 4 1 | 11 | 18 |
| 436 | 5454.170 | 5454.144 | 4 4 1 | 3 3 0 | 110 | 18 |
| 436 | 5454.170 | 5454.170 | 5 4 1 | 4 4 0 | 11 | 18 |
| 437 | 5454.280 | 5454.283 | 8 1 8 | 7 1 7 | 11 | 18 |
| 438 | 5454.376 | 5454.365 | 4 4 0 | 3 3 1 | 110 | 18 |
| 438 | 5454.376 | 5454.379 | 8 0 8 | 7 0 7 | 11 | 18 |
| 439 | 5457.799 | 5457.798 | 3 2 1 | 2 0 2 | 11 | 18 |
| 440 | 5462.351 | 5462.346 | 9 4 6 | 9 2 7 | 11 | 18 |
| 441 | 5463.792 | 5463.791 | 5 4 2 | 4 4 1 | 11 | 17 |
| 442 | 5464.262 | 5464.232 | 8 4 5 | 8 2 6 | 11 | 18 |
| 443 | 5464.396N | 5464.396 | 8 0 8 | 7 0 7 | 11 | 17 |
| 444 | 5464.624 | 5464.625 | 3 3 0 | 3 1 3 | 11 | 18 |
| 445 | 5464.724 | 5464.729 | 9 1 8 | 9 1 9 | 11 | 18 |
| 446 | 5465.412 | 5465.413 | 6 3 4 | 5 3 3 | 11 | 18 |
| 447 | 5466.283 | 5466.287 | 9 2 8 | 9 0 9 | 11 | 18 |
| 448 | 5466.972 | 5466.971 | 7 2 6 | 6 2 5 | 11 | 18 |
| 449 | 5468.537N | 5468.537 | 9 1 9 | 8 1 8 | 11 | 18 |
| 450 | 5468.572N | 5468.572 | 9 0 9 | 8 0 8 | 11 | 18 |
| 451 | 5470.520 | 5470.519 | 7 1 6 | 6 1 5 | 11 | 18 |
| 452 | 5470.871 | 5470.869 | 7 4 4 | 7 2 5 | 11 | 18 |
| 453 | 5471.674N | 5471.677 | 6 2 4 | 5 2 3 | 11 | 18 |
| 454 | 5473.160N | 5473.161 | 6 3 3 | 5 3 2 | 11 | 18 |
| 455 | 5476.260 | 5476.260 | 5 4 2 | 4 3 1 | 110 | 18 |
| 456 | 5476.944N | | 7 2 6 | 6 2 5 | 11 | 17 |
| 457 | 5477.334 | 5477.334 | 6 4 3 | 5 4 2 | 11 | 18 |
| 458 | 5477.803 | 5477.802 | 5 4 1 | 4 3 2 | 110 | 18 |
| 459 | 5478.190N | 5478.190 | 6 4 2 | 5 4 1 | 11 | 18 |
| 460 | 5478.558 | | 9 1 9 | 8 1 8 | 11 | 17 |
| 461 | 5478.681 | 5478.681 | 6 3 3 | 5 2 4 | 110 | 18 |
| 462 | 5479.841 | 5479.835 | 4 3 1 | 4 1 4 | 11 | 18 |
| 463 | 5481.178 | 5481.177 | 4 3 2 | 3 0 3 | 110 | 18 |
| 464 | 5481.628 | | 6 2 4 | 5 2 3 | 11 | 17 |
| 465 | 5482.191N | 5482.191 | 10 1 10 | 9 1 9 | 11 | 18 |
| 466 | 5482.213N | 5482.218 | 10 0 10 | 9 0 9 | 11 | 18 |
| 467 | 5482.742N | | 6 3 3 | 5 3 2 | 11 | 17 |
| 468 | 5484.222 | 5484.221 | 8 2 7 | 7 2 6 | 11 | 18 |
| 469 | 5486.660N | 5486.660 | 7 3 5 | 6 3 4 | 11 | 18 |
| 470 | 5488.720N | 5488.720 | 6 5 2 | 5 5 1 | 11 | 18 |
| 471 | 5488.752N | 5488.752 | 6 5 1 | 5 5 0 | 11 | 18 |
| 472 | 5491.448 | 5491.447 | 5 4 2 | 5 2 3 | 11 | 18 |
| 473 | 5494.476N | 5494.480 | 7 2 5 | 6 2 4 | 11 | 18 |
| 474 | 5494.542N | 5494.543 | 4 2 2 | 3 0 3 | 11 | 18 |
| 475 | 5495.287N | 5495.288 | 11 1 11 | 10 1 10 | 11 | 18 |
| 475 | 5495.287N | 5495.296 | 11 0 11 | 10 0 10 | 11 | 18 |
| 476 | 5496.057 | 5496.056 | 6 4 3 | 5 3 2 | 110 | 18 |
| 477 | 5496.386N | | 8 1 7 | 7 1 6 | 11 | 17 |
| 478 | 5496.491N | | 7 3 5 | 6 3 4 | 11 | 17 |
| 479 | 5498.595 | | 6 5 2 | 5 5 1 | 11 | 17 |
| 479 | 5498.595 | | 6 5 1 | 5 5 0 | 11 | 17 |
| 480 | 5498.762 | 5498.761 | 7 3 4 | 6 3 3 | 11 | 18 |
| 461 | 5500.289N | 5500.308 | 6 2 4 | 5 1 5 | 110 | 18 |
| 481 | 5500.289N | 5500.289 | 7 4 4 | 6 4 3 | 11 | 18 |
| 482 | 5500.626N | 5500.628 | 9 2 8 | 8 2 7 | 11 | 18 |
| 483 | 5501.534 | 5501.533 | 9 1 8 | 8 1 7 | 11 | 18 |
| 484 | 5501.706 | 5501.707 | 6 4 2 | 5 3 3 | 110 | 18 |
| 485 | 5502.767 | 5502.767 | 7 4 3 | 6 4 2 | 11 | 18 |
| 486 | 5506.839N | 5506.640 | 8 3 6 | 7 3 5 | 11 | 18 |
| 487 | 5511.407 | 5511.404 | 3 3 0 | 2 1 1 | 11 | 18 |
| 488 | 5511.911 | 5511.907 | 7 5 3 | 6 5 2 | 11 | 18 |
| 489 | 5512.065 | 5512.066 | 7 5 2 | 6 5 1 | 11 | 18 |
| 490 | 5512.956 | 5512.956 | 7 4 4 | 6 3 3 | 110 | 18 |
| 491 | 5514.656N | 5514.656 | 8 2 6 | 7 2 5 | 11 | 18 |
| 492 | 5516.019 | 5516.019 | 10 2 9 | 9 2 6 | 11 | 18 |
| 493 | 5516.520 | 5516.520 | 10 1 9 | 9 1 8 | 11 | 18 |
| 494 | 5517.115 | 5517.116 | 4 4 0 | 4 2 3 | 11 | 18 |
| 495 | 5517.633 | 5517.630 | 8 4 5 | 7 3 4 | 110 | 18 |
| 496 | 5519.812 | 5519.812 | 13 1 13 | 12 1 12 | 11 | 18 |
| 496 | 5519.812 | 5519.812 | 13 0 13 | 12 0 12 | 11 | 18 |
| 497 | 5520.247 | 5520.248 | 7 3 4 | 6 2 5 | 110 | 18 |
| 498 | 5522.559 | 5522.561 | 8 4 5 | 7 4 4 | 11 | 18 |
| 499 | 5524.071 | 5524.065 | 7 6 1 | 6 6 0 | 11 | 18 |
| 499 | 5524.071 | 5524.065 | 7 6 2 | 6 6 1 | 11 | 18 |
| 500 | 5524.852 | | 8 2 6 | 7 2 5 | 11 | 17 |
| 501 | 5525.880 | 5525.880 | 9 3 7 | 8 3 6 | 11 | 18 |
| 502 | 5526.991 | 5526.991 | 3 3 1 | 2 1 2 | 11 | 18 |
| 503 | 5527.451 | 5527.451 | 7 4 3 | 6 3 4 | 110 | 18 |
| 504 | 5528.132N | 5528.133 | 8 4 4 | 7 4 3 | 11 | 18 |
| 505 | 5530.783 | 5530.780 | 4 3 1 | 3 1 2 | 11 | 18 |
| 506 | 5530.903 | 5530.903 | 11 2 10 | 10 2 9 | 11 | 18 |
| 507 | 5530.959N | 5530.958 | 8 3 5 | 7 3 4 | 11 | 18 |
| 508 | 5531.138 | 5531.138 | 11 1 10 | 10 1 9 | 11 | 18 |

Table 2 lists values of the levels obtained from the present data on the (011), (110) states of $H_2{}^{18}O$ and $H_2{}^{17}O$. They were obtained from the ground state levels given for this work in Table 1 and the measured line frequencies. The (011) band is much stronger than the (110) band for respective isotopic species and therefore the majority of the $H_2{}^{18}O$ and $H_2{}^{17}O$ observations were of lines in the (011) band. The two entries given in Table 2 for the (110) state of $H_2{}^{17}O$ were derived from transitions for which the line strengths are enhanced due to Coriolis mixing of the (110) state levels with levels in the (011) state. In fact many levels in the (011) state are affected by Coriolis interactions with levels in the (110) state for either molecule. The magnitude of the mixing which these levels exhibit in $H_2{}^{16}O$ is presented in a paper by Camy-Peyret and Flaud (*6*).

TABLE 3—*Continued*

| Line No. | Frequency ($CM^{-1}$) (Obs.) | (Calc.) | Upper State $JK_{-1}K_1$ | | | Lower State $JK_{-1}K_1$ | | | Band | Mol. |
|---|---|---|---|---|---|---|---|---|---|---|
| 509 | 5531.376 | | | | | | | | | |
| 510 | 5532.295 | 5532.295 | 9 | 2 | 7 | 8 | 2 | 6 | 11 | 18 |
| 511 | 5532.536 | 5532.531 | 6 | 4 | 2 | 6 | 2 | 5 | 11 | 18 |
| 512 | 5533.553 | 5533.545 | 6 | 3 | 3 | 6 | 1 | 6 | 11 | 18 |
| 513 | 5534.778 | 5534.778 | 8 | 5 | 4 | 7 | 5 | 3 | 11 | 18 |
| 514 | 5535.350 | 5535.352 | 8 | 5 | 3 | 7 | 5 | 2 | 11 | 18 |
| 515 | 5539.891 | 5539.891 | 5 | 2 | 3 | 4 | 0 | 4 | 11 | 18 |
| 516 | 5543.783 | 5543.783 | 10 | 3 | 8 | 9 | 3 | 7 | 11 | 18 |
| 517 | 5543.915 | 5543.917 | 9 | 4 | 6 | 8 | 4 | 5 | 11 | 18 |
| 518 | 5545.193 | 5545.193 | 12 | 2 | 11 | 11 | 2 | 10 | 11 | 18 |
| 519 | 5545.345 | 5545.345 | 12 | 1 | 11 | 11 | 1 | 10 | 11 | 18 |
| 520 | 5546.935 | 5546.927 | 8 | 6 | 3 | 7 | 6 | 2 | 11 | 18 |
| 520 | 5546.935 | 5546.936 | 8 | 6 | 2 | 7 | 6 | 1 | 11 | 18 |
| 521 | 5548.183 | 5548.183 | 10 | 2 | 8 | 9 | 2 | 7 | 11 | 18 |
| 522 | 5552.714 | 5552.713 | 5 | 3 | 2 | 4 | 1 | 3 | 11 | 18 |
| 523 | 5552.856 | 5552.856 | 9 | 3 | 6 | 8 | 3 | 5 | 11 | 18 |
| 524 | 5553.954 | 5553.954 | 9 | 4 | 5 | 8 | 4 | 4 | 11 | 18 |
| 525 | 5557.213 | 5557.212 | 9 | 5 | 5 | 8 | 5 | 4 | 11 | 18 |
| 526 | 5558.775 | 5558.775 | 9 | 5 | 4 | 8 | 5 | 3 | 11 | 18 |
| 527 | 5559.012 | 5559.012 | 13 | 2 | 12 | 12 | 2 | 11 | 11 | 18 |
| 528 | 5559.130 | 5559.130 | 13 | 1 | 12 | 12 | 1 | 11 | 11 | 18 |
| 529 | 5559.400 | 5559.400 | 8 | 7 | 2 | 7 | 7 | 1 | 11 | 18 |
| 529 | 5559.400 | 5559.400 | 8 | 7 | 1 | 7 | 7 | 0 | 11 | 18 |
| 530 | 5560.608 | 5560.608 | 11 | 3 | 9 | 10 | 3 | 8 | 11 | 18 |
| 531 | 5560.703 | 5560.704 | 4 | 3 | 2 | 3 | 1 | 3 | 11 | 18 |
| 532 | 5563.253 | 5563.253 | 11 | 2 | 9 | 10 | 2 | 8 | 11 | 18 |
| 533 | 5564.210 | 5564.210 | 10 | 4 | 7 | 9 | 4 | 6 | 11 | 18 |
| 534 | 5569.410 | 5569.410 | 9 | 6 | 4 | 8 | 6 | 3 | 11 | 18 |
| 535 | 5569.530 | 5569.530 | 9 | 6 | 3 | 8 | 6 | 2 | 11 | 18 |
| 536 | 5573.638 | 5573.638 | 10 | 3 | 7 | 9 | 3 | 6 | 11 | 18 |
| 537 | 5578.983 | 5578.983 | 10 | 4 | 6 | 9 | 4 | 5 | 11 | 18 |
| 538 | 5580.535 | 5580.530 | 6 | 3 | 3 | 5 | 1 | 4 | 11 | 18 |
| 539 | 5582.595 | 5582.595 | 10 | 5 | 5 | 9 | 5 | 4 | 11 | 18 |
| 540 | 5583.369 | 5583.369 | 11 | 4 | 8 | 10 | 4 | 7 | 11 | 18 |
| 541 | 5583.444 | | | | | | | | | |
| 542 | 5592.789 | 5592.789 | 6 | 2 | 4 | 5 | 0 | 5 | 11 | 18 |
| 543 | 5598.644 | 5598.644 | 5 | 3 | 3 | 4 | 1 | 4 | 11 | 18 |
| 544 | 5604.938 | 5604.937 | 4 | 4 | 0 | 3 | 2 | 1 | 11 | 18 |
| 545 | 5616.184 | 5616.191 | 7 | 3 | 4 | 6 | 1 | 5 | 11 | 18 |
| 546 | 5620.812 | | | | | | | | | |
| 547 | 5637.826 | 5637.825 | 6 | 4 | 2 | 5 | 2 | 3 | 11 | 18 |
| 548 | 5637.984 | 5637.985 | 5 | 4 | 2 | 4 | 2 | 3 | 11 | 18 |

The magnitude of the mixing of the levels in $H_2{}^{18}O$ and $H_2{}^{17}O$ for these states is comparable to that in $H_2{}^{16}O$.

Table 3 is a listing of the line numbers, measured and calculated line center frequencies, upper and lower state rotational quantum numbers, band, and isotopic species. The line numbers pertain to the numbering of the absorptions shown in Fig. 1. Absorptions not numbered in Fig. 1 are due to $H_2{}^{16}O$. The calculated frequencies given in Table 3 were determined from the upper state levels given in Table 2 and the ground state values, of this study, given in Table 1. The measured frequencies denoted by an "N" in Table 3 refer to measurements taken from very high resolution interferometric spectra of $H_2{}^{16}O$ (*2*). A few of the measured lines given in Table 3 do not have quantum assignments (for example, line numbers 96, 98, 110, 133, etc.) and they may be due to yet unidentified transitions in the (011) and (110) bands of $H_2{}^{18}O$ and $H_2{}^{17}O$ or "hot" band transitions of $H_2{}^{18}O$, mainly in the (021)–(010) band. Also quantum assignments were made for a few lines for which the calculated frequencies were not determined (for example, line numbers 3, 14, 88, 110, etc.) because either or both the upper and lower state levels could not be obtained from the data.

TABLE 4

Positions ($cm^{-1}$) of $H_2{}^{18}O/H_2{}^{17}O$ and $H_2{}^{16}O$ lines which were blended in the spectral data.

| Position | Upper Level $J\ K_{-1}K_1$ | Lower Level $J\ K_{-1}K_1$ | Band | Mol. |
|---|---|---|---|---|
| 5113.827 | 4 0 4 | 5 1 5 | 110 | 18 |
| 5113.872 | 9 2 8 | 10 2 9 | 011 | 16 |
| 5125.731 | 5 1 5 | 5 3 2 | 011 | 18 |
| 5125.709 | 2 1 1 | 3 2 2 | 110 | 16 |
| 5134.773 | 9 1 9 | 9 1 8 | 011 | 18 |
| 5134.779 | 8 2 7 | 9 2 8 | 011 | 16 |
| 5156.951 | 3 2 1 | 3 3 0 | 110 | 18 |
| 5157.007 | 4 1 4 | 4 2 3 | 110 | 16 |
| 5159.981 | 6 4 3 | 7 4 4 | 011 | 18 |
| 5159.937 | 6 3 3 | 7 3 4 | 011 | 16 |
| 5243.834 | 2 1 1 | 3 1 2 | 011 | 17 |
| 5243.889 | 3 2 2 | 4 2 3 | 011 | 16 |
| 5246.292 | 2 0 2 | 2 2 1 | 011 | 18 |
| 5246.303 | 3 3 0 | 4 3 1 | 011 | 16 |
| 5261.519 | 6 2 5 | 6 2 4 | 011 | 18 |
| 5261.501 | 2 2 0 | 3 2 1 | 011 | 16 |
| 5269.181 | 1 1 0 | 2 1 1 | 011 | 17 |
| 5269.136 | 2 1 2 | 3 1 3 | 011 | 16 |
| 5277.461 | 2 1 2 | 1 0 1 | 110 | 18 |
| 5277.482 | 4 1 4 | 4 1 3 | 011 | 16 |
| 5282.348 | 5 2 4 | 5 2 3 | 011 | 18 |
| 5282.355 | 4 2 2 | 4 1 3 | 110 | 16 |
| 5291.714 | 4 1 3 | 3 2 2 | 110 | 18 |
| 5291.706 | 2 1 2 | 1 0 1 | 110 | 16 |
| 5314.175 | 4 2 3 | 4 2 2 | 011 | 17 |
| 5314.148 | 7 3 5 | 7 3 4 | 011 | 16 |
| 5314.594 | 5 2 4 | 5 1 5 | 110 | 18 |
| 5314.518 | 5 3 2 | 5 2 3 | 110 | 16 |
| 5326.610 | 5 3 3 | 5 3 2 | 011 | 17 |
| 5326.646 | 3 3 0 | 3 2 1 | 110 | 16 |
| 5337.705 | 2 1 1 | 2 1 2 | 011 | 17 |
| 5337.702 | 5 3 3 | 5 3 2 | 011 | 16 |
| 5338.562 | 8 5 4 | 8 5 3 | 011 | 18 |
| 5338.517 | 4 0 4 | 3 2 1 | 011 | 16 |
| 5338.534 | 5 3 3 | 5 2 4 | 110 | 16 |
| 5338.762 | 3 2 2 | 2 1 1 | 110 | 18 |
| 5338.755 | 2 2 0 | 2 2 1 | 011 | 16 |
| 5343.413 | 3 1 2 | 3 1 3 | 011 | 18 |
| 5343.419 | 5 5 1 | 5 5 0 | 011 | 18 |
| 5343.423 | 5 5 0 | 5 5 1 | 011 | 18 |
| 5343.403 | 3 2 1 | 3 2 2 | 011 | 16 |
| 5353.083 | 7 6 2 | 7 6 1 | 011 | 18 |
| 5353.090 | 7 6 1 | 7 6 2 | 011 | 18 |
| 5353.110 | 4 2 3 | 3 1 2 | 110 | 18 |
| 5353.072 | 5 4 1 | 5 4 2 | 011 | 16 |
| 5357.159 | 4 4 1 | 4 3 2 | 110 | 18 |
| 5357.136 | 8 4 4 | 8 4 5 | 011 | 16 |
| 5363.190 | 2 1 2 | 1 1 1 | 011 | 17 |
| 5363.143 | 7 3 4 | 7 3 5 | 011 | 16 |
| 5399.589 | 4 1 4 | 3 1 3 | 011 | 17 |
| 5399.632 | 4 3 2 | 5 1 5 | 011 | 16 |
| 5427.469 | 4 3 2 | 4 1 3 | 011 | 18 |
| 5427.496 | 6 1 5 | 6 1 6 | 011 | 16 |
| 5433.097 | 3 3 1 | 3 1 2 | 011 | 18 |
| 5433.119 | 8 2 6 | 8 2 7 | 011 | 16 |
| 5434.884 | 6 3 4 | 5 2 3 | 110 | 18 |
| 5434.922 | 4 1 3 | 3 1 2 | 011 | 16 |
| 5447.046 | 5 2 3 | 4 1 4 | 110 | 18 |
| 5447.056 | 5 3 3 | 5 1 4 | 011 | 16 |
| 5449.902 | 8 2 7 | 8 0 8 | 011 | 18 |
| 5449.863 | 2 2 0 | 1 0 1 | 011 | 16 |
| 5486.220 | 8 1 7 | 7 1 6 | 011 | 18 |
| 5486.214 | 6 3 4 | 5 3 3 | 011 | 16 |
| 5507.838 | 12 0 12 | 11 0 11 | 011 | 18 |
| 5507.831 | 12 1 12 | 11 1 11 | 011 | 18 |
| 5507.828 | 8 1 7 | 7 1 6 | 011 | 16 |

Several $H_2{}^{18}O$ and $H_2{}^{17}O$ lines were blended with $H_2{}^{16}O$ lines in the spectra to an extent that measurements of their line positions could not be made with any accuracy. Table 4 is a listing of these lines along with their quantum and band assignments. The $H_2{}^{16}O$ frequencies are those given in Ref. (*2*) and the $H_2{}^{18}O$ and $H_2{}^{17}O$ values were calculated from the ground state levels, of this work, given in Table 1 and the upper state levels listed in Table 2.

Table 5 lists the measured line strengths of $H_2{}^{18}O$. For comparison purposes, those transitions for which measurements of $H_2{}^{16}O$ line strengths were made (*3*) are also given in terms of the product with the $^{18}O/^{16}O$ ratio; 0.00209. Inspection of the $H_2{}^{18}O$ and $H_2{}^{16}O$ results indicate that, to good approximation, $H_2{}^{18}O$ line strengths can be calcu-

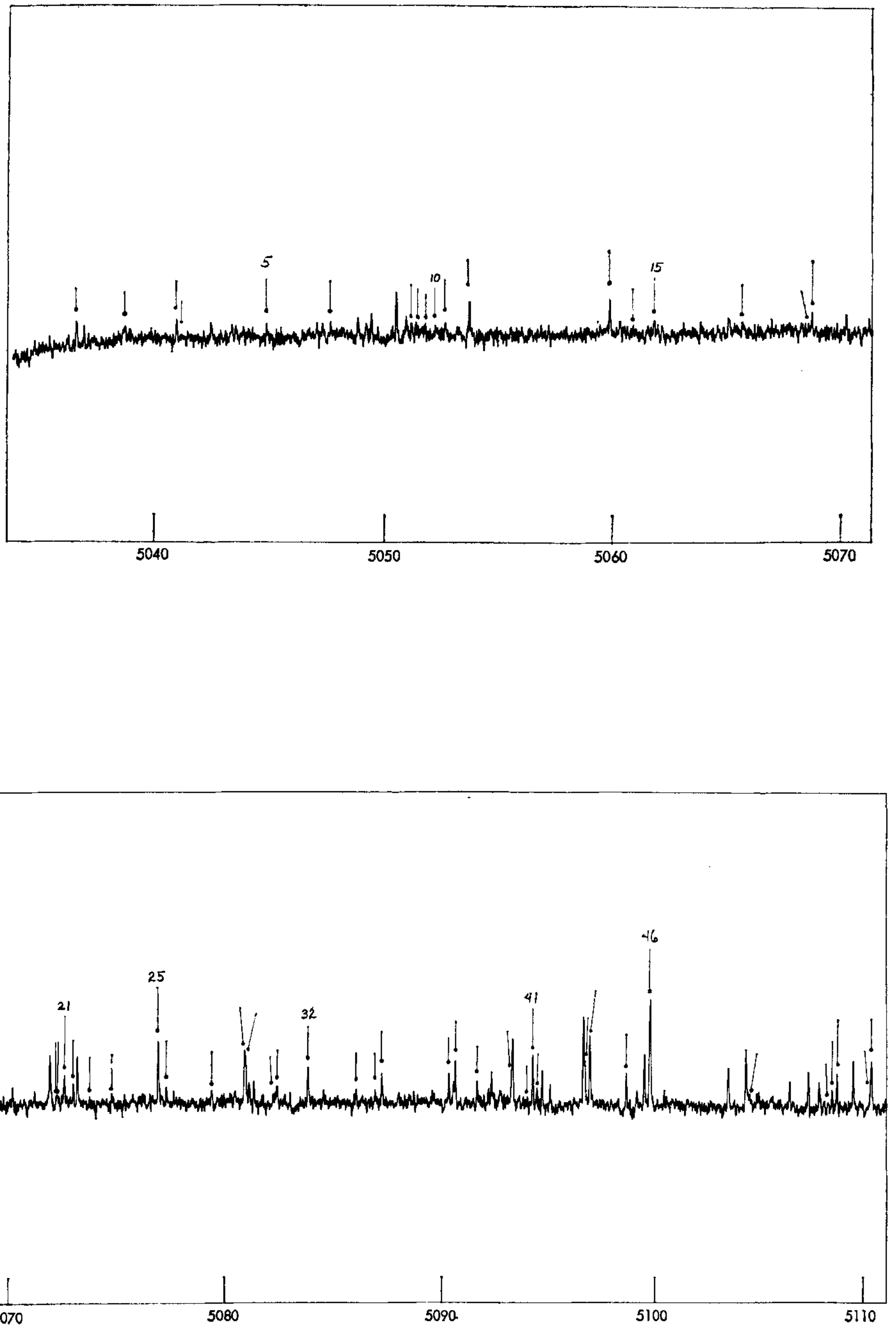
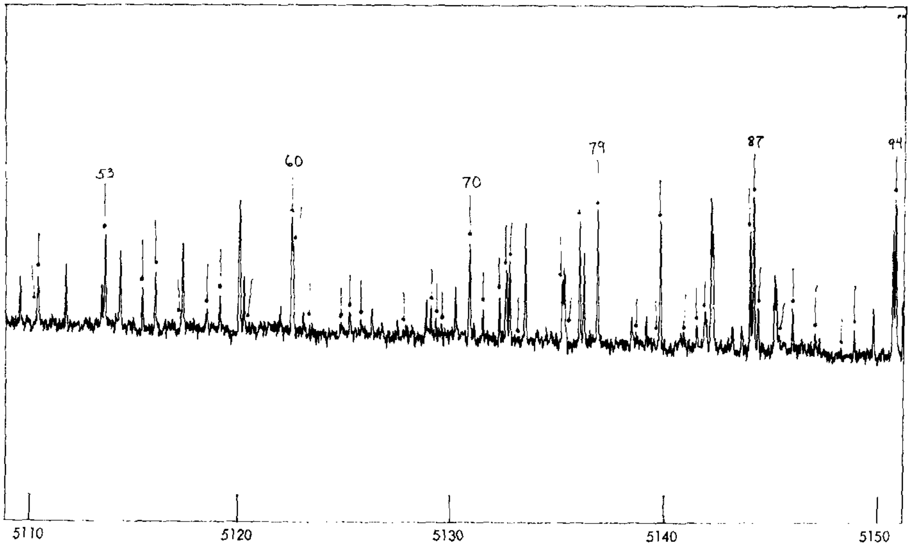



FIG. 1. Scan of the 5030 to 5640 cm$^{-1}$ region of $H_2{}^{18}O$, $H_2{}^{16}O$, and $H_2{}^{17}O$. The sample pressure was 2.3 Torr and the path was 48 m. The isotopic ratio of the water vapor sample was 50, 50, and 0.1% for $H_2{}^{18}O$, $H_2{}^{16}O$, and $H_2{}^{17}O$, respectively. The stroke marks denote the $H_2{}^{18}O$ and $H_2{}^{17}O$ lines and only these are numbered.



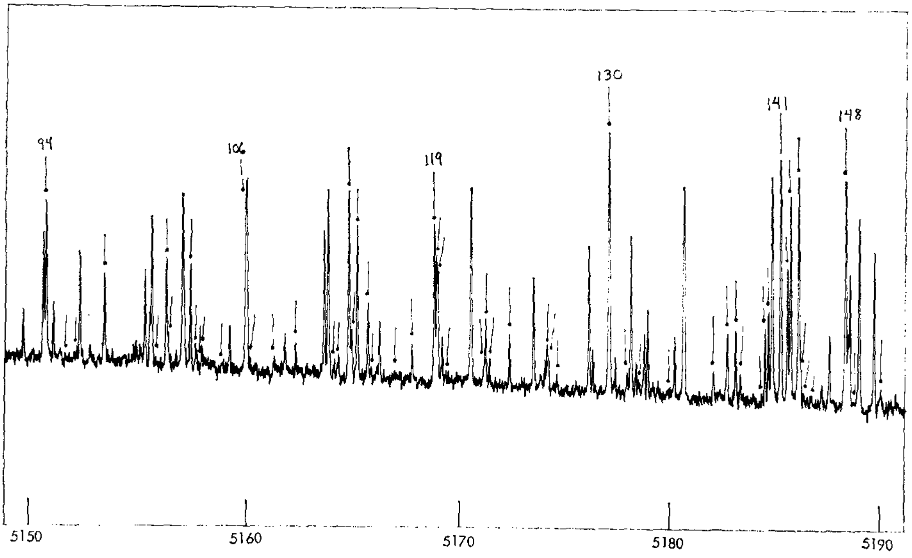
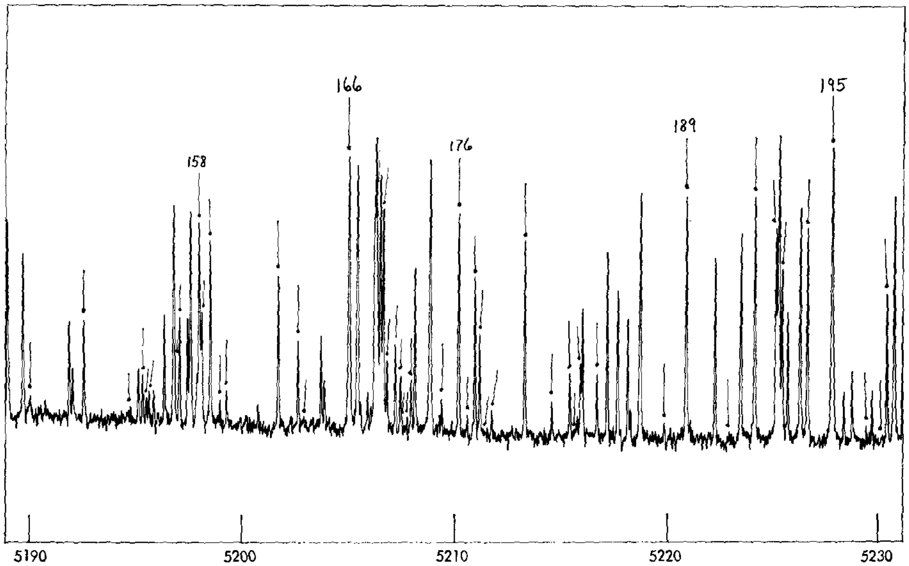




FIG. 1—*Continued*



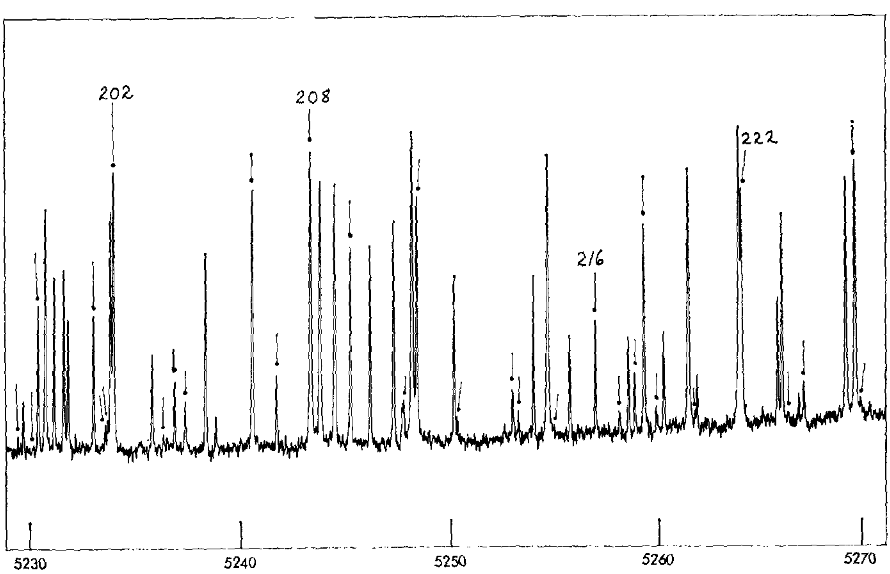
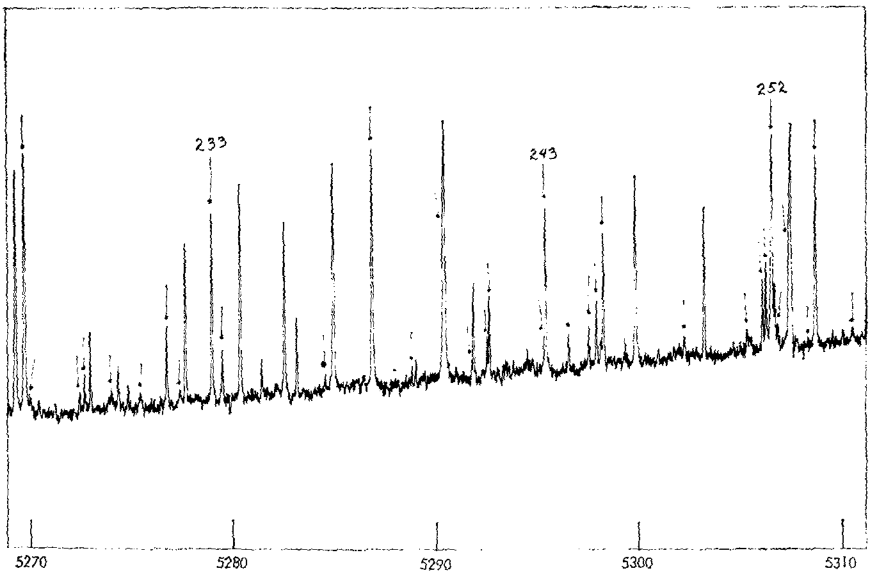




FIG. 1—*Continued*



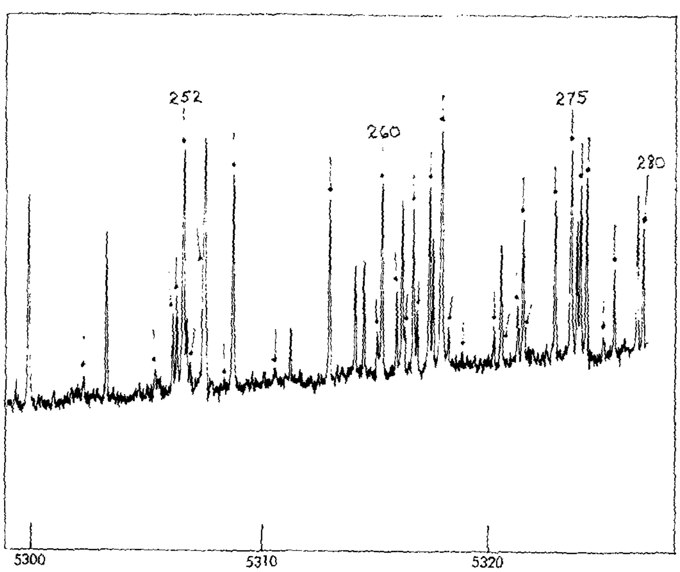
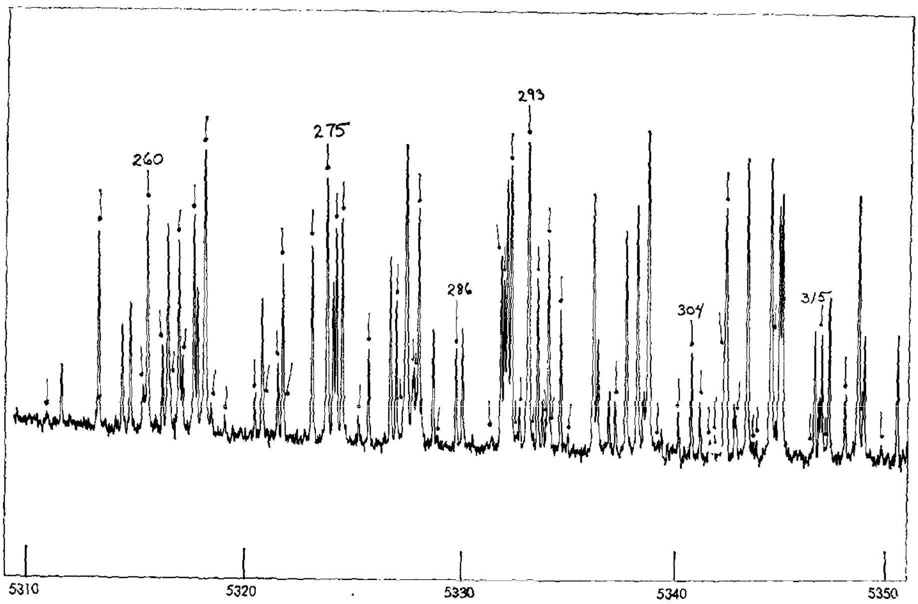




FIG. 1—*Continued*



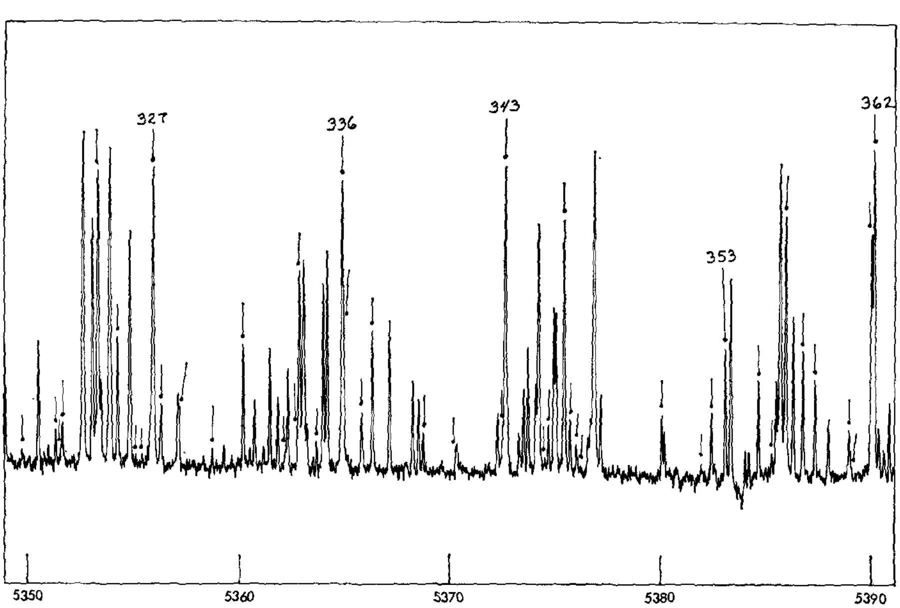
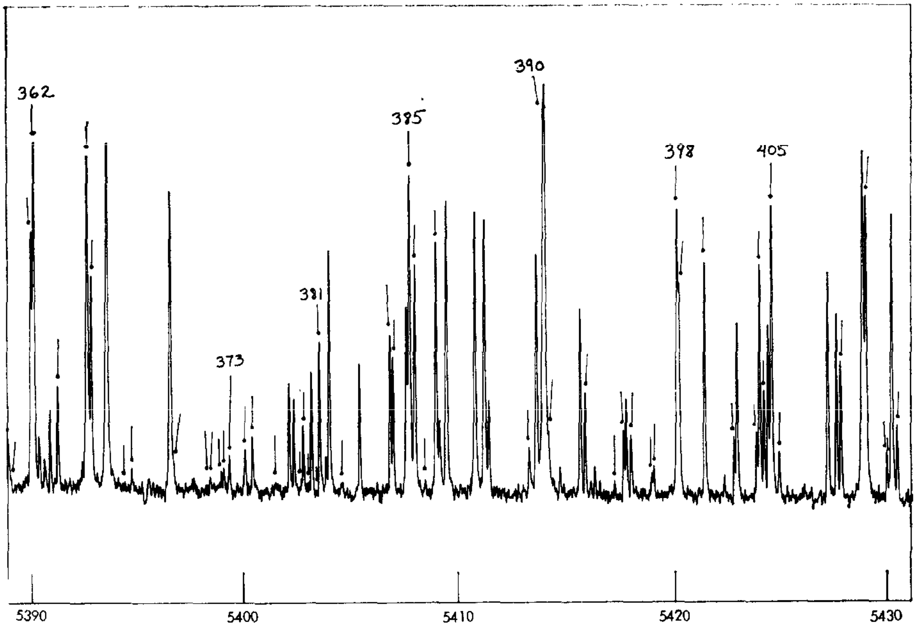




FIG. 1—*Continued*



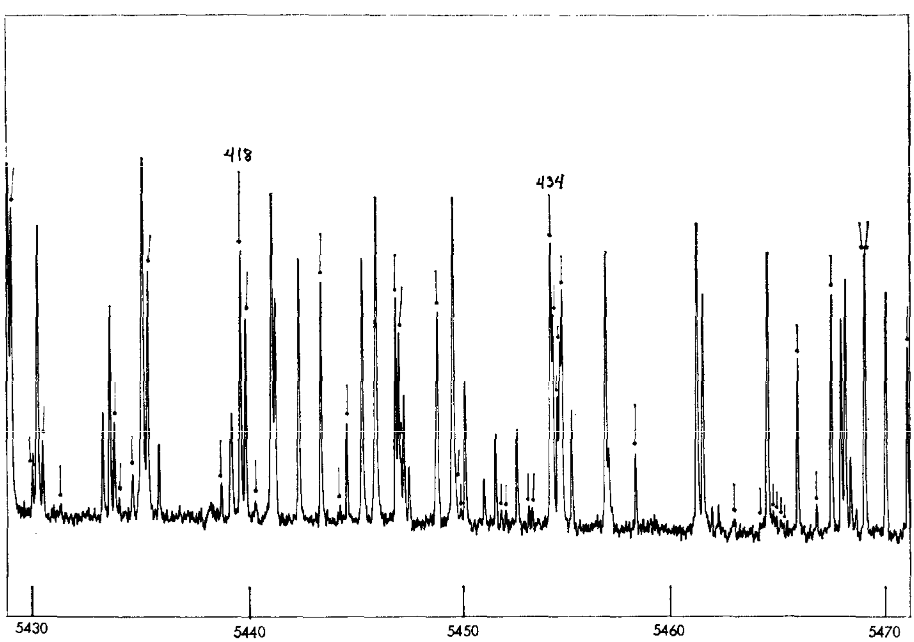
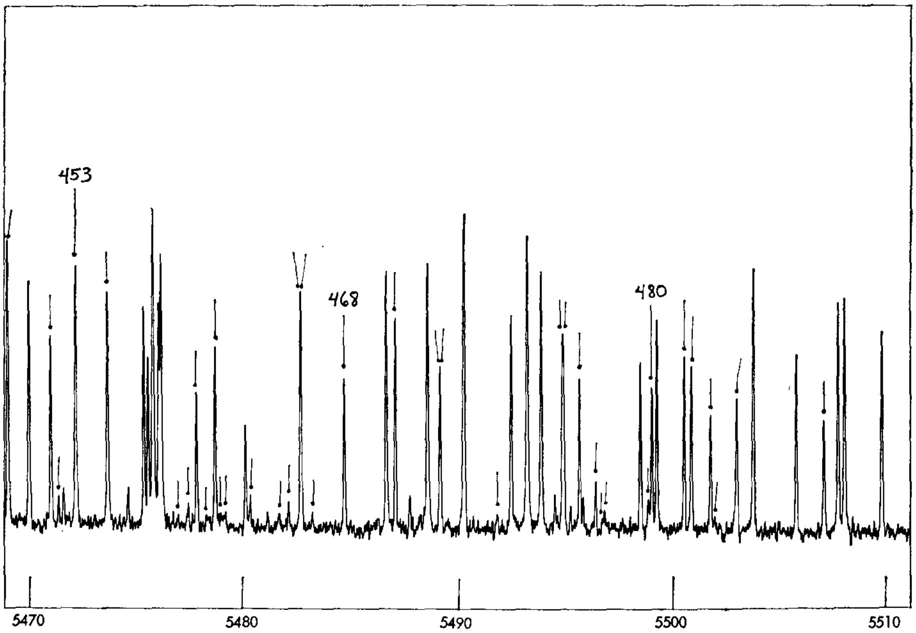




FIG. 1—*Continued*



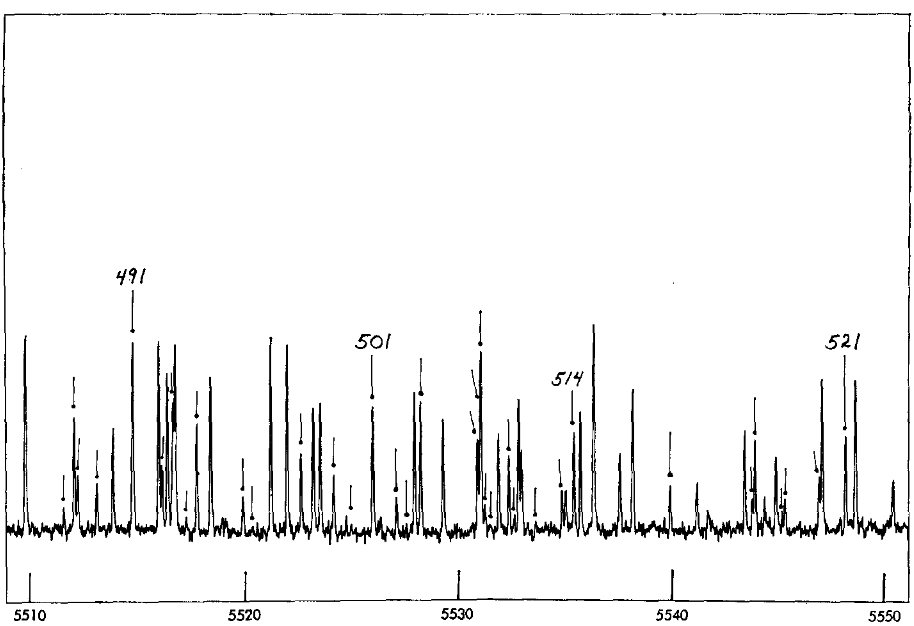
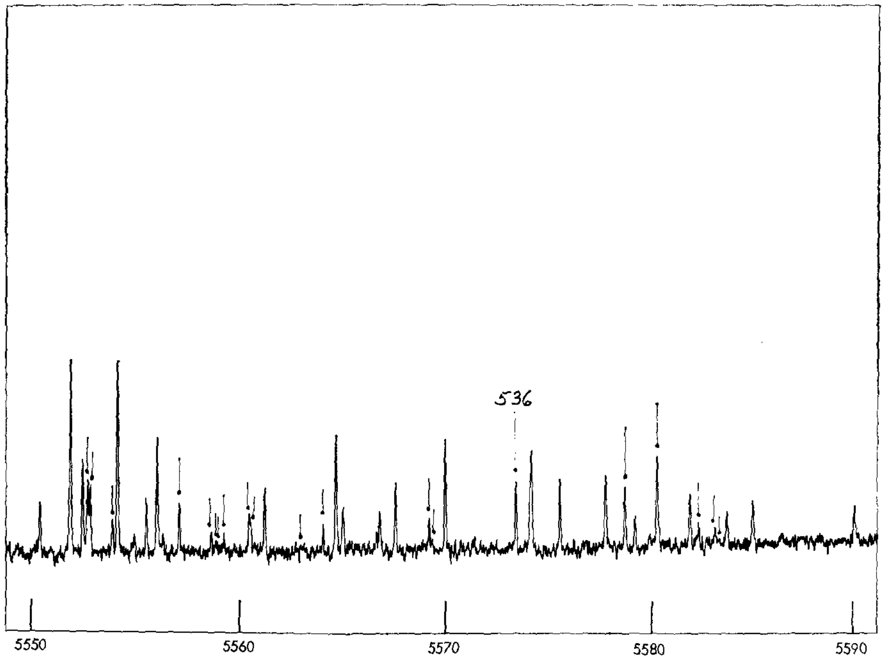




FIG. 1—*Continued*



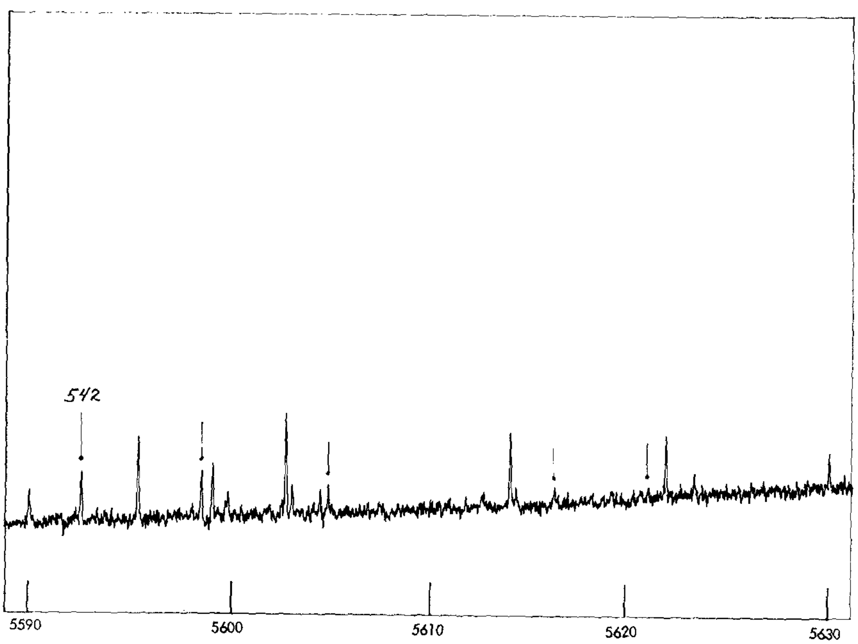




FIG. 1—*Continued*

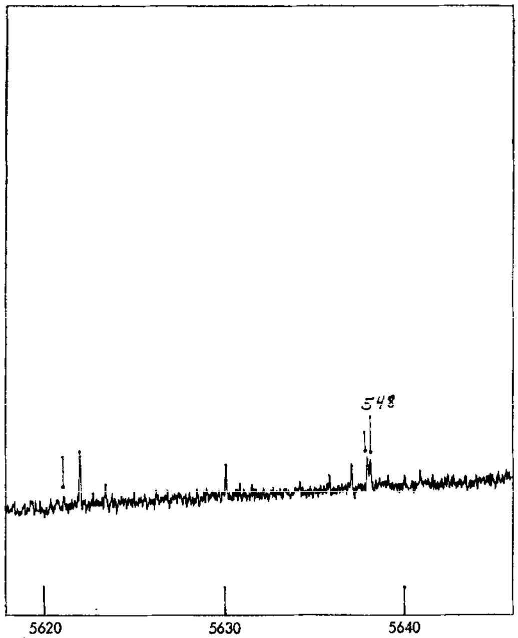



FIG. 1—*Continued*

TABLE 5

Line strengths of $H_2{}^{18}O$ in the (011) band measured from spectra of $H_2{}^{16}O$. Strength in $cm^{-2}\ atm^{-1}$ at 296K.

| Frequency ($cm^{-1}$) | Upper State $J\ K_{-1}K_1$ | Lower State $J\ K_{-1}K_1$ | Strength $H_2{}^{18}O$ | Strength $I \times H_2{}^{16}O$[a] | Upper State Level Perturbed[b] |
|---|---|---|---|---|---|
| 5186.115 | 5 1 5 | 6 1 6 | 4.76-4 | 5.46-4 | NO |
| 5205.039 | 4 0 4 | 5 0 5 | 6.10-4 | | NO |
| 5210.178 | 3 1 2 | 4 1 3 | 2.30-4 | 2.53-4 | NO |
| 5243.431 | 2 0 2 | 3 0 3 | 9.35-4 | | NO |
| 5269.578 | 1 1 1 | 2 1 2 | 6.29-4 | | NO |
| 5306.544 | 1 1 1 | 1 1 0 | 8.02-4 | 8.17-4 | NO |
| 5317.974 | 2 2 0 | 2 2 1 | 1.08-3 | | NO |
| 5322.968 | 3 2 1 | 3 2 2 | 1.88-4 | 1.96-4 | YES |
| 5323.674 | 3 3 1 | 3 3 0 | 7.20-4 | | NO |
| 5324.373 | 4 3 1 | 4 3 2 | 3.65-4 | 4.63-4 | YES |
| 5327.964 | 2 1 1 | 2 1 2 | 6.30-4 | | NO |
| 5356.013 | 2 0 2 | 1 0 1 | 1.16-3 | | NO |
| 5372.690 | 3 1 3 | 2 1 2 | 1.12-3 | | NO |
| 5375.491 | 3 0 3 | 2 0 2 | 4.25-4 | | NO |
| 5392.749 | 4 0 4 | 3 0 3 | 1.37-3 | | NO |
| 5407.885[c] | 4 3 1 | 3 2 2 | 2.02-4 | 1.43-4 | YES |
| 5408.871 | 5 0 5 | 4 0 4 | 2.45-4 | | NO |
| 5421.357 | 4 3 1 | 3 3 0 | 2.90-4 | 2.71-4 | YES |
| 5439.669 | 7 0 7 | 6 0 6 | 1.96-4 | 1.59-4 | NO |
| 5443.182 | 5 3 3 | 4 3 2 | 3.14-4 | 3.14-4 | YES |
| 5453.846 | 6 1 5 | 5 1 4 | 5.07-4 | | NO |
| 5453.959 | 5 4 2 | 4 4 1 | 1.29-4 | 9.69-5 | NO |
| 5478.190 | 6 4 2 | 5 4 1 | 1.14-4 | 1.13-4 | YES |

a. $I = H_2{}^{18}O/H_2{}^{16}O = 0.00209$. $H_2{}^{16}O$ strengths from ref (3)

b. From $H_2{}^{16}O$ mixing coefficients given in ref (6).

c. (110) band.

lated from the $H_2{}^{16}O$ values. The last column in Table 5 indicates if the upper state level is perturbed or not as inferred from the mixing coefficients given by Camy–Peyret and Flaud (*6*) for the states (030), (011), and (110) of $H_2{}^{16}O$. The uncertainty in the $H_2{}^{18}O$ measured line strength values is $\pm 10\%$.

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